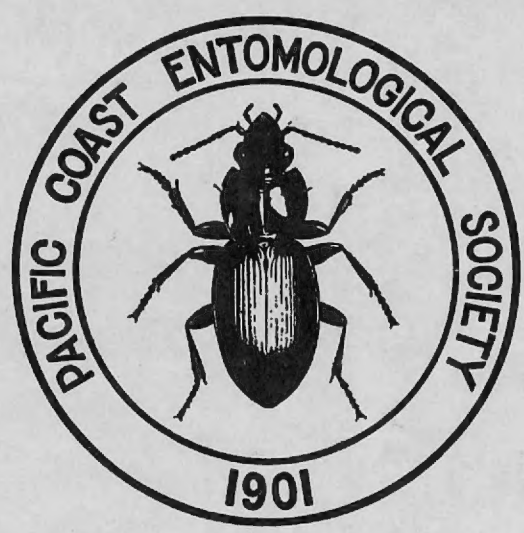


THE
PAN-PACIFIC ENTOMOLOGIST



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Multivariate Analysis of Geographic Variation in *Libellula luctuosa* Burmeister

(Odonata: Libellulidae)

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The study of intraspecific variation in dragonflies has rarely proceeded beyond the naming and describing of new taxa. This is partly due to the paucity of material at hand: dragonflies are seldom collected and the ranges even of many common species are poorly known. Most of the papers analyzing geographic variation in odonates (Bennefield, 1965; Huggins, 1927; Johnson, 1972) have involved tabulation of characters, with taxonomic decisions usually based on observable differences in features such as color, size, shape, or wing maculation. Multivariate methods of classification may be extremely helpful to the odonate systematist, especially when populations intergrade and variation among different characters is discordant. This paper analyzes geographic variation in a common and widespread species and compares the results of four multivariate methods of analysis for consistency.

Libellula luctuosa Burmeister is a large, dark dragonfly with black basal wing bands which occurs over most of the United States except the Great Basin and Florida. It occurs in British Columbia, Quebec, Manitoba, and Nova Scotia and is known in Mexico from Chihuahua and Durango. Variation in coloration, maculation, or size might be expected, since it ranges from mesic northeastern deciduous forests to cattle ponds of the hot, arid Southwest.

Three different phenotypes of *L. luctuosa* were subjectively recognized by the author; their distribution is shown in Figure 1. From southern Canada and the Atlantic coast to the eastern edge of the Great Plains, *L. luctuosa* is characterized by uniformly dark hind wing bands (Fig. 4a). From the edge of the Great Plains south through Oklahoma, eastern Colorado, Texas, New Mexico, southeastern Arizona, and Mexico, populations possess various degrees of hind wing clearing (Fig. 4a-d). Hagen (1861) described these paler individuals as a new species, *Libellula odiosa*, but subsequently (1875) reduced *L. odiosa* to a race

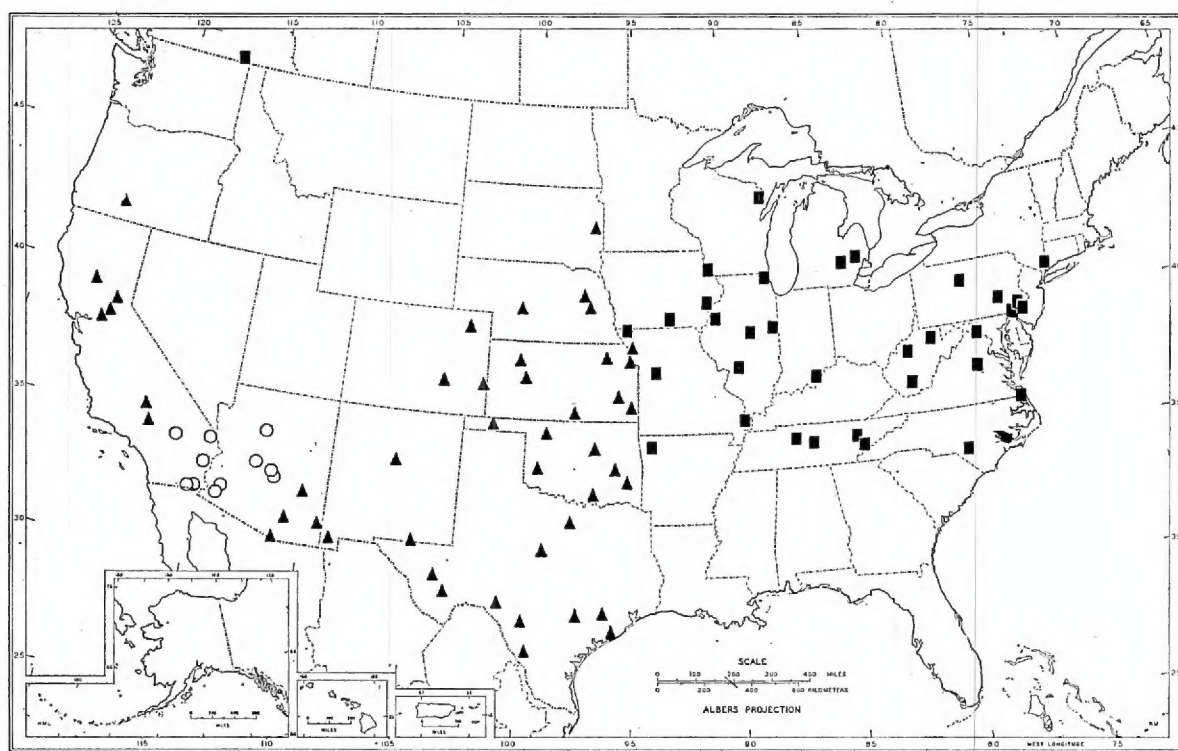


FIG. 1. Map of specimen localities, *Libellula luctuosa*. Solid squares = eastern *luctuosa* morphs, solid triangles = *odiosa* morphs, open circles = Colorado River phenotypes. More than one specimen may have been taken at some localities.

of *L. luctuosa*. Most authors since have considered *L. odiosa* a variety or synonym of *L. luctuosa* (Calvert, 1906; Needham and Westfall, 1955; Ris, 1910). These individuals are hereafter called *odiosa*, though the taxon is believed to be synonymous with eastern *L. luctuosa*. The *odiosa*

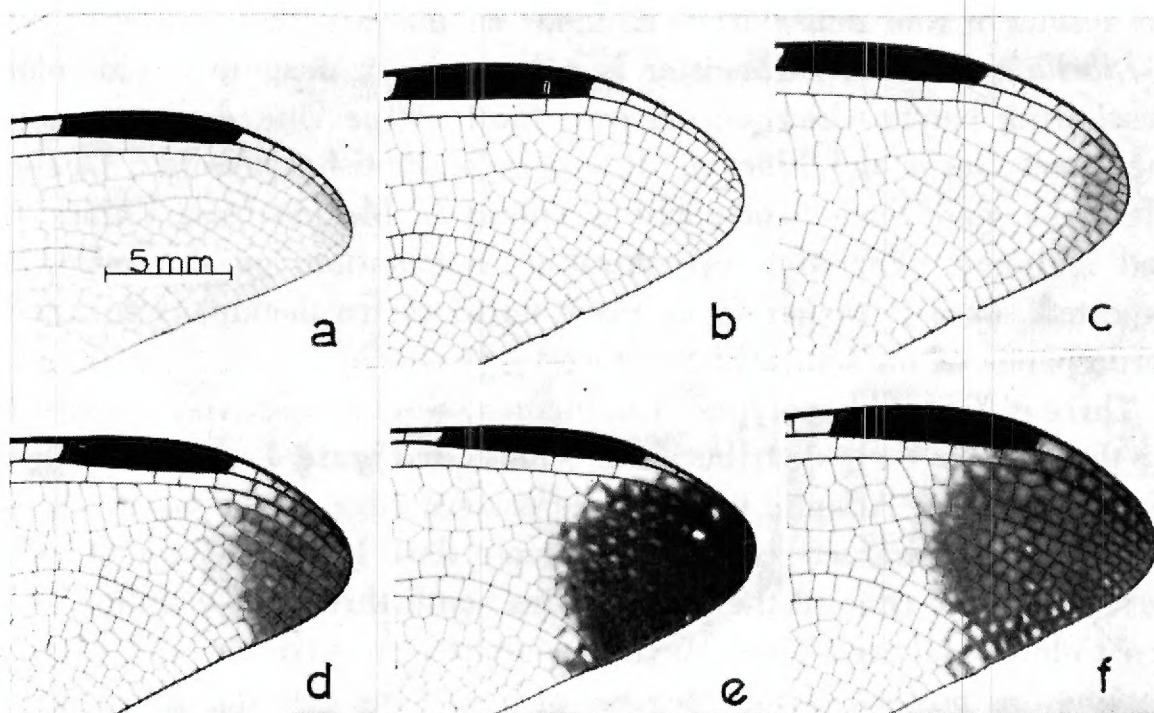


FIG. 2. Coded examples for wingtip coloration width and length. a = present, b = 1 (absent), c = 3, d = 5, e = 8, f = 9 (brown to midpoint of pterostigma).

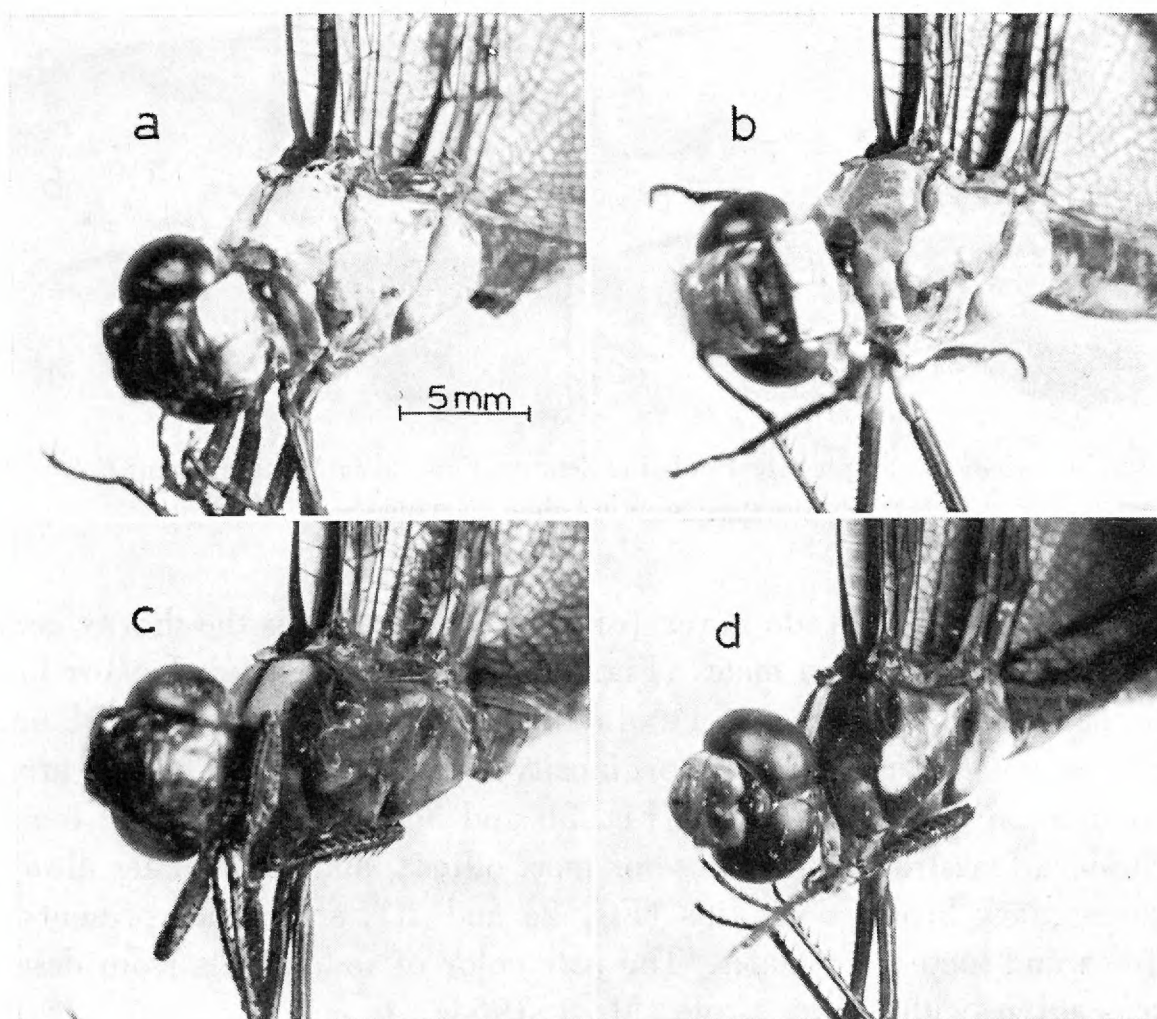


FIG. 3. Thoracic patterns of *Libellula luctuosa*. a. male Colorado River morph (Blythe, Riverside Co., Calif.), b. female Colorado River morph (Blythe, Riverside Co., Calif.), c. male (Peña Blanca Lake, Santa Cruz Co., Ariz.), d. female (Peña Blanca Lake, Santa Cruz Co., Ariz.). Both sexes of the odiosa and luctuosa morphs have thoracic patterns as in c. and d.

phenotype intergrades with nominate *L. luctuosa* west of the Mississippi River and in the Edwards Plateau region of central Texas. Allopatric populations of the odiosa phenotype also occur within the Central Valley and foothills of the Sierra Nevada of California north of the Tehachapi Mountains to southern Oregon. A single male from Robson, British Columbia, has no clearing in the hind wing band and is classified in this study as nominate *L. luctuosa*.¹

A third group of populations inhabits the Sonoran, Colorado, and Mojave deserts and is separated from the Central Valley populations by the Tehachapi Mountains, and from the southeastern Arizona populations by the eastern edge of the Sonoran Desert. This phenotype, known

¹ Both the British Columbia (American Museum of Natural History) and Oregon males (H. G. Dyar collection at the U.S. National Museum) are probably mislabeled. The Oregon locale is Crater Lake, 29 July 1920. *Libellula luctuosa* has been taken at the Klamath River immediately south of the Oregon border.

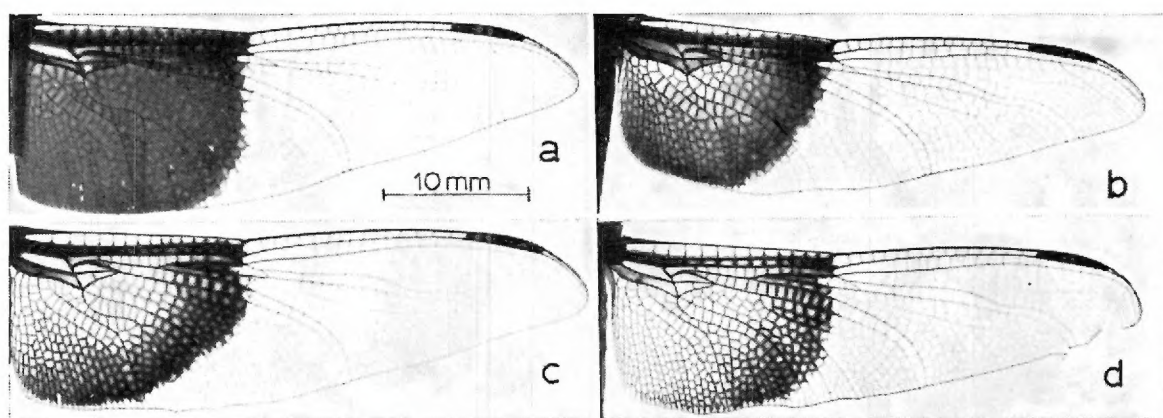


FIG. 4. Coded examples for hindwing fenestration. a = 1 (no clearing), b = 3, c = 8, d = 12 (maximum extent of hindwing clearing).

hereafter as the Colorado River (or desert) morph, has the thorax completely pruinose blue in males (Fig. 3a), while pruinosity is localized on the mesepisternum in *luctuosa* and *odiosa* phenotypes (Fig. 3c). Mature females possess a violaceous pruinosity over the typical brown areas found in *odiosa* and *luctuosa* (Fig. 3b and 3d). The hind wing bands are more fenestrated than those of most *odiosa*, and the females always possess dark brown wing tips (Fig. 2e and 2f), sometimes present in *odiosa* and *luctuosa* females. The pale color of individuals from desert areas agrees with Gloger's rule (Mayr, 1963).

The author subjected the data from nearly 200 *Libellula luctuosa*, intuitively classified by the characters discussed above and enumerated in Table 1, to the following multivariate means of classification: 1) principal component analysis, 2) step-wise discriminant analysis, 3) linear discriminant analysis, and 4) hierarchical numerical taxonomic methods. *Libellula luctuosa*, with its broad spectrum of geographic variation and widespread distribution (Fig. 1), is a suitable species for this study. The purpose of the study was to test compatibility of results of various methods and to compare those results with the author's intuitive concept of recognizing the species as three geographical entities, as well as to describe and explain patterns of morphological variation.

METHODS AND MATERIALS

Variation in *L. luctuosa* was analyzed using 116 males and 72 females from 26 states and provinces shown in Figure 1. A total of 10 specimens (five males and five females), if available, was chosen from each state. More individuals were chosen from Texas due to its size, and from California and Arizona because the Colorado River morph is apparently restricted to those two states.

TABLE 1. Characters.

A. Measured Characters

1. **HINDWING:** Linear distance from humeral plate to tip of wing.
2. **PTEROSTIGMA:** Linear distance along costal margin of hindwing.
3. **INTERPOLATED ANKLE CELLS IN ANAL LOOP:** Number of enclosed cells between veins A_1 and A_2 but not adjacent to those veins. Ankle cells lie on either side of the midrib.
4. **GAFF:** Linear distance between hind angle of hindwing triangle and heel of anal loop.
5. **SOLE:** Linear distance from heel to toe of anal loop.
6. **MIDDORSAL THORACIC STRIPE WIDTH:** Width measured near the antalar sinuses. Absence of stripe, as in Colorado River phenotype males, = 1; for other individuals, a value of 1 was added to the width measurement.
7. **METATHORACIC FEMUR:** Length along ventral side.
8. **METATHORACIC TIBIA:** Length along ventral side from distal end to concavity before articulation point.
9. **ABDOMINAL SEGMENT 5:** Length along lateral carina.
10. **SUPERIOR CAUDAL APPENDAGES:** Length along dorsal surface of superior caudal appendages of males or cerci of females.

B. Coded Characters

11. **WINGTIP COLORATION WIDTH:** Brown in anterior one-fourth of wingtip. Coded 1 (absent) (FIG. 2b) or 2 (present) (FIG. 2a). Present only on some male Colorado River morphs.
12. **WINGTIP COLORATION LENGTH:** Length of brown on wingtip. Character states ranged from 1 (no brown) to 9 (brown to midpoint of pterostigma) (FIG. 2b-f).
13. **THORACIC COLORATION:** Absence (1) or presence (2) of pale mazarine (pruinose) blue on sides of synthorax (mesepimeron, metepisternum, metepimeron). Present only on male Colorado River phenotype (FIG. 3a).
14. **FOREWING FENESTRATION:** Absence (1) or presence (2) of clearing within brown forewing band of males. As almost all individuals possessed some degree of clearing, this character was included to test its importance relative to other characters. The light area in the mid-basal space in fore- and hindwings is typical of all populations and was not included.
15. **HIND WING FENESTRATIONS:** Degree of fenestration in the hindwing band, coded 1 (no fenestration posterior to mid-basal space) to 12 (hindwing clear from midbasal space to two or three cells anterior to toe of anal loop).
16. **FRONS:** Color coded: 1) maize yellow, 2) aniline yellow, 3) Isabella color, dark olive buff, or deep chrome, 4) olive brown or dark olive, and 5) metallic black. Frons coded by the color covering 50% or more of its surface.
17. **ANTECLYPEUS:** Color coded as above.

(TABLE 1. Cont.)

18. LABIUM: Color coded as above.
19. MIDDORSAL THORACIC STRIPE COLOR: Coded as for frons with one additional color state: 6) pale mazarine (pruinose) blue.
20. PROTHORACIC FEMUR: Color of ventral sides coded as for mid-dorsal thoracic stripe color.

Appropriate portions of the U.C.L.A. BIOMED program series as modified for the U.C.B. computer center were used in this study. Patterns of variation were also analyzed by numerical taxonomic methods (Sneath and Sokal, 1973), using the NT-PAK (Numerical Taxonomy Package by W. W. Moss and L. N. Bell). The data were run on the CDC-6400 computer at the University of California Computer Center at Berkeley. Because fully mature *L. luctuosa* are sexually dimorphic, males and females were run separately.

CHARACTERS

Only mature or juvenile natural adult specimens were used in this study. Presence of pruinosity, a characteristic whitish bloom present on many male Libellulidae, was the basis for selecting mature males. Pruinosity is often destroyed on preserved specimens by heat (Pinhey, 1951), chemical solvents, or leakage of body oils. Excessive heat can also cause the wings and body to glisten like teneral immediately after eclosion. The types of *L. odiosa* are in this condition and were so described by Hagen (1861): "Entirely brassy-black . . .," and Muttkowski (1908) separated *L. odiosa* from *L. luctuosa* by this means. No females with glistening wing membranes nor teneral specimens were used because their coloration and maculation differ from mature adults and because many tenerals were in poor morphological condition, preventing accurate measurements. Juvenile specimens possess a hard cuticle but lack fully developed pruinosity patterns. The accessory genitalia of males, usually of great taxonomic importance in dragonflies, showed no consistent differences, and were not used. Post-mortem color changes in a few poorly preserved specimens, especially females, were recorded, even though these changes were probably unnatural. Missing characters for about 6% of the specimens were substituted by values from similar specimens of the same size. These conditions constitute some of the inherent errors common to any phenetic study of organisms.

All continuous characters except hind wing length were measured to the nearest 0.01 mm using an ocular micrometer. Repeated measure-

TABLE 2. Factor Loadings for Characters of *L. luctuosa*. Important loadings ($-.200 > \alpha > .200$) are underlined.

Character	Males Principal Component			Females Principal Component	
	I	II	III	I	II
Hindwing	<u>-.239</u>	<u>-.385</u>	.099	<u>-.376</u>	.180
Pterostigma	<u>-.325</u>	<u>-.117</u>	-.004	<u>-.376</u>	.136
Ankle Cells	.047	<u>-.317</u>	<u>-.277</u>	<u>-.158</u>	.150
Gaff	-.134	<u>-.263</u>	.025	<u>-.269</u>	.101
Sole	.136	<u>-.431</u>	.089	<u>-.131</u>	.349
Middorsal	<u>.332</u>	<u>-.225</u>	-.033	<u>-.188</u>	<u>-.123</u>
Stripe Width					
Femur	<u>-.258</u>	<u>-.275</u>	.093	<u>-.360</u>	.129
Tibia	<u>-.302</u>	<u>-.181</u>	.031	<u>-.318</u>	.097
Abdominal Segment					
5 Length	<u>-.226</u>	<u>-.264</u>	.033	<u>-.312</u>	.203
Caudal Appendages	<u>-.182</u>	<u>-.267</u>	-.086	<u>-.113</u>	.145
Wingtip Width	-.190	.185	.001	—	—
Wingtip Length	.098	-.063	.013	<u>-.156</u>	<u>-.358</u>
Thoracic Color	<u>-.362</u>	.234	-.103	—	—
FW Fenestration	<u>-.041</u>	.020	-.021	<u>-.034</u>	-.056
HW Fenestration	<u>-.335</u>	.117	-.030	<u>-.279</u>	<u>-.172</u>
Frons	<u>-.076</u>	.052	.620	<u>.188</u>	<u>.379</u>
Clypeus	.171	-.119	<u>.296</u>	<u>.215</u>	<u>.346</u>
Labium	.221	-.181	<u>.290</u>	<u>.017</u>	<u>.229</u>
Middorsal Stripe	<u>-.263</u>	.101	<u>.297</u>	.141	<u>.346</u>
Color					
Prothoracic Leg	.048	.123	<u>.478</u>	.149	<u>.306</u>
Color					
Percentage of Total Variation	28%	14%	8%	27%	18%

ments revealed an error of about 5%. A standard millimeter rule was used for the hind wing measurement. Of the 20 characters listed in Table 2, only 18 were recorded for females. The blue thoracic coloration and wingtip width characters were not present in females. Color terminology is after Ridgway (1912) and morphological terminology is after Needham and Westfall (1955).

ANALYTICAL TECHNIQUES

Multivariate techniques simultaneously compare all character values over each OTU (Operational Taxonomic Unit). Many authors have utilized these techniques for biological material, including Moss (1967), Moulton (1973) and Rohlf (1968) for principal components, Barlow, Graham and Adisoemarto (1969) and Bigelow and Reimer (1954) for linear discriminant analysis, and Rohwer and Kilgore (1973) and Rohwer (1972) using both methods. Numerical taxonomic methods are elaborated in Sneath and Sokal (1973).

Principal component analysis was first used because a prior assignment of specimens into arbitrary reference groups is not necessary. Combinations of characters representing OTU's are transformed to uncorrelated axes represented in an n-dimensional hyperspace. Principal axes are then established within this hyperspace so that each OTU can be expressed by its spatial relationship to n-number of components. The first component accounts for the greatest percentage of variation, the second accounts for the next greatest percentage of variation, and so on until all variation over all OTU's is expressed. Factor loadings for all characters provide a basis for determining which characters are discriminatory and which are uncorrelated. One hundred sixteen males (20 characters) and 72 females (18 characters) were analyzed.

Step-wise discriminant and linear discriminant analysis require an assignment of OTU's into arbitrary groups of known entities. The first involves a multiple discriminant analysis in a step-wise manner, whereby variables having the highest F-values (discriminatory ratio value of each value compared to the sum values of previously entered variables) are repeatedly selected for discrimination between groups. Each succeeding step utilizes the preceding combination of variables, adding another variable either with the next higher F-value, or with an F-value which, when combined with the previous set of variables, yields the greatest separation of groups. With each iteration, variables yielding the highest F-values are determined and the overlap and misclassification of OTU's between groups are recorded. Since many museum specimens are affected by post-mortem color and pruinosity pattern changes, only continuous characters were utilized to determine their value in classifying OTU's. The data were run in two groups for each sex, one with 10 characters (hindwing, pterostigma, ankle cells, gaff, sole, middorsal thoracic stripe width, femur, tibia, abdominal segment 5, and superior caudal appendages), the other including an eleventh character, hindwing fenestration, to determine its importance in further separating the groups. Twenty-five specimens from each phenotypic

group, if available, were compared. Since only 13 female Colorado River females were available, 32 odiosa females were included so that the total number of OTU's would approximate that for the males.

Linear discriminant analysis for two groups defines an axis through multidimensional clusters of OTU's resulting in a maximum separation of the clusters. Coefficients for each character are provided and these multiplied by their respective character value and summed, resulting in a single score or z-value for each OTU which can then be plotted on a histogram. From the histogram, unassigned specimens can be plotted in the same manner prescribed for reference specimens, and their position relative to the two end groups determined. Linear discriminant analysis provides an objective means by which unknown OTU's can be classified; only specimens with z-values intermediate between the two reference samples cannot with assurance be assigned to either group.

Calculation of z-values for each taxon is most advantageous when only a few characters are used. The use of many characters complicates the computational procedure and defeats the simplicity of the method. Bicoded qualitative characters which are easily discernible need not be used, since the observer can easily segregate his samples into like phena. Therefore, only four continuous variables were used: sole length, hind-wing fenestration, middorsal thoracic stripe width, and femur length. The four characters repeatedly ranked with high F-values above the other seven variables in the step-wise discriminant program.

The NT 11 package used in this study performs character standardization by variance, ranking of similarity coefficients, cluster analysis using unweighted pair group averages (UPGA), histogram, and minimally connected network (Primnet: Prim, 1957). The phenograms were based on average linkage and represent a one-dimensional clustering of OTU's by similarity coefficients. The Primnets represent a one-dimensional linkage of OTU's by lines of similarity based on taxonomic distance. The longer the line between OTU's, the less similar the OTU's. The relative position of non-linked OTU's to each other is arbitrary and does not denote similarity.

RESULTS

Principal Component Analysis.—The spatial relationships of the three phenotypes are depicted in Figures 5 and 6 for males and Figure 7 for females. The squares, triangles, and circles throughout this study represent luctuosa, odiosa, and Colorado River morphs, respectively. The first scattergram for each sex shows the OTU's in relation to the first and second components; the second set for males shows the OTU's in

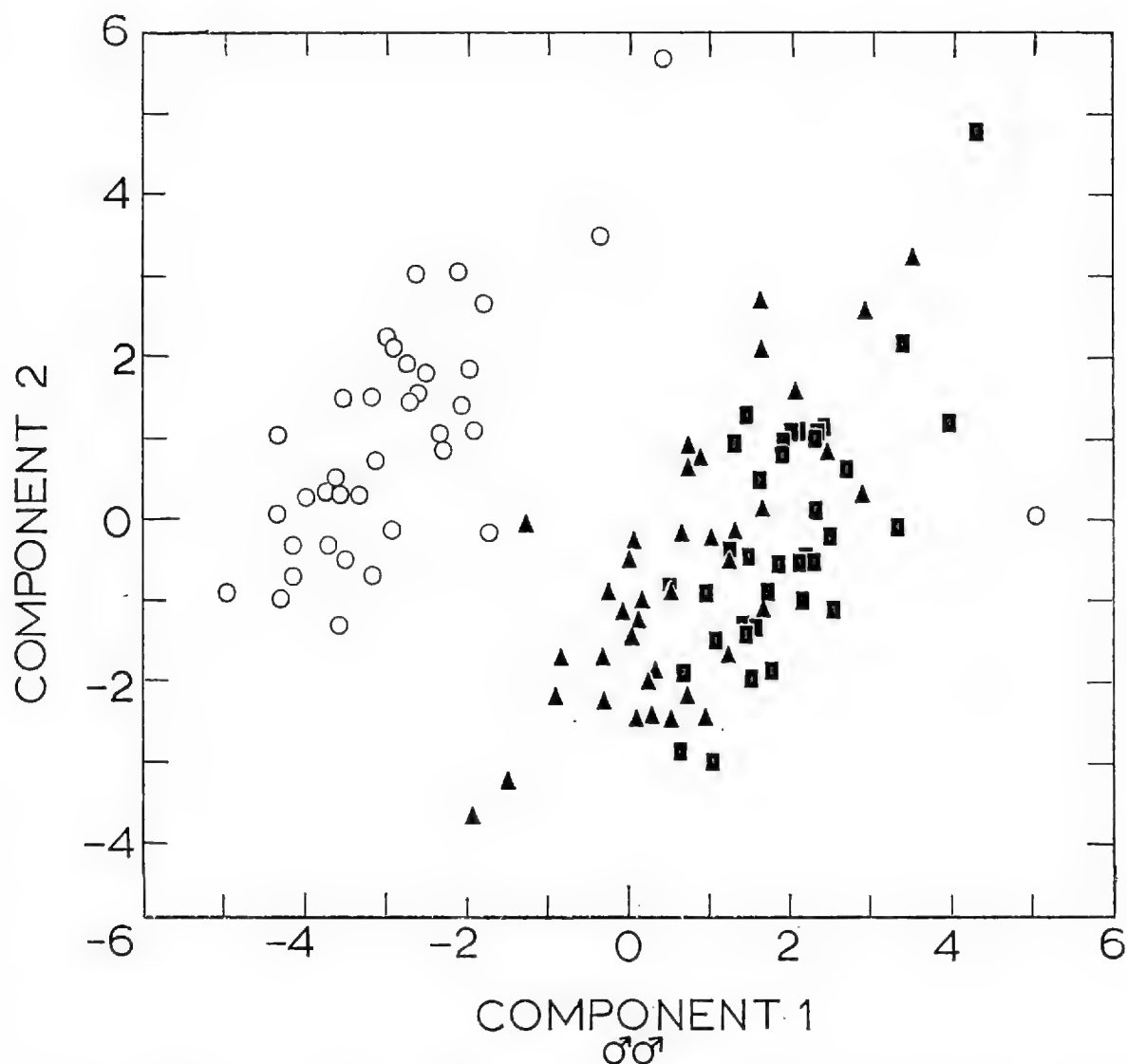


FIG. 5 (above) and FIG. 6 (right). Scattergram of principal component scores for males. Open circles = Colorado River morphs, solid triangles = *odiosa*, and solid squares = *eastern luctuosa*. Distribution of symbols indicates overall phenetic similarity to other morphs. Continuous measured characters (Table 2) are primarily responsible for separation of Colorado River and *odiosa-luctuosa* morphs in Fig. 5. Color-coded characters (Table 2) are primarily responsible for separation of morphs in Fig. 6.

relation to the first and third components. Clusters of OTU's for males are defined by combining both graphs.

Factor loadings for males (20 characters) are listed in Table 2. Only wingtip color length and forewing fenestration resulted in uniformly low values ($-.100 < \alpha < .100$) for the first three components, indicating that these characters were not important in segregating the groups. A combination of continuous and coded characters was important in separating the various groups. Measured characters primarily showed the highest factor loadings ($-.300 > \alpha > .300$) on the first two components. Highest coefficients were for hindwing (component 2), ptero-

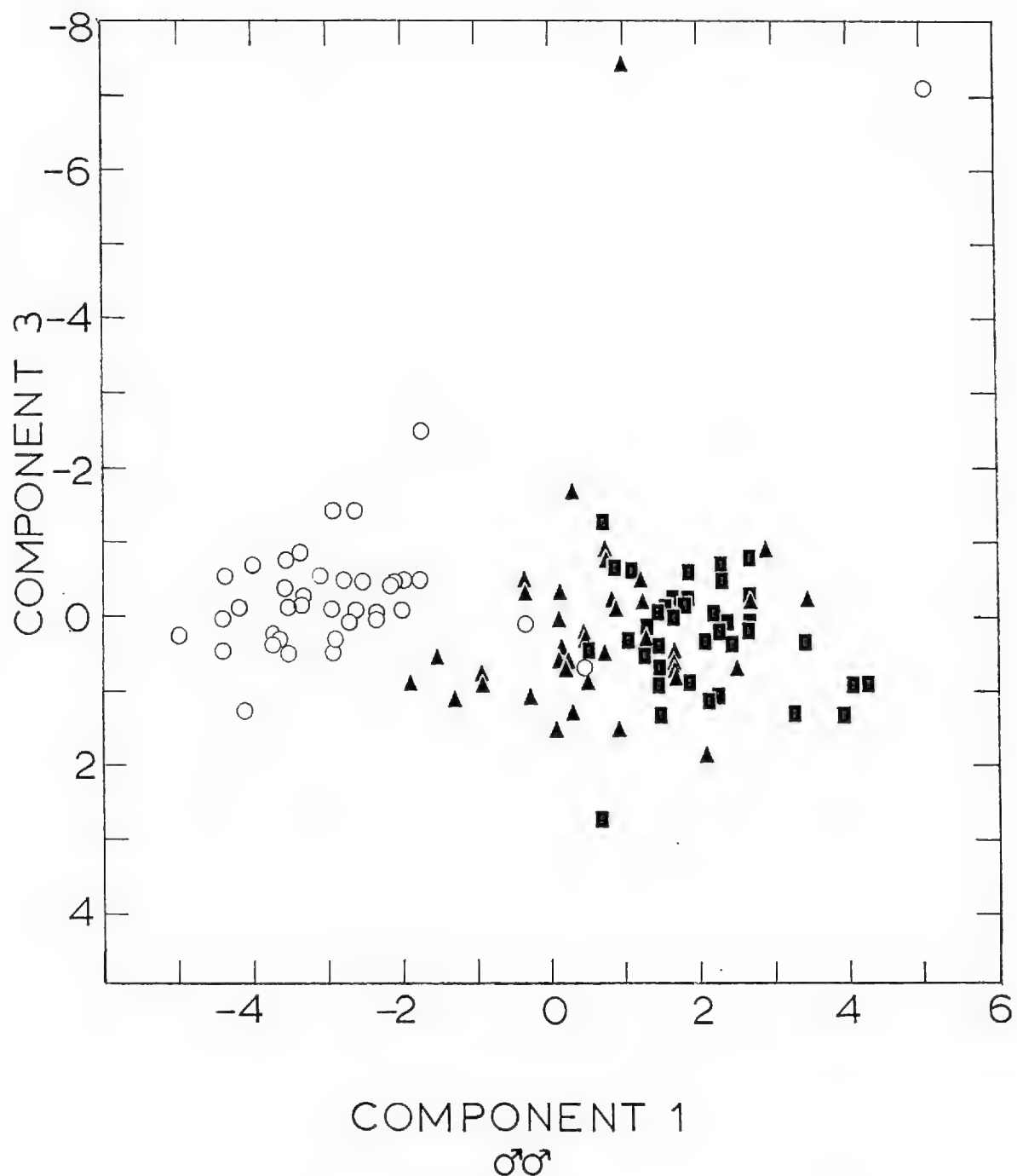


FIG. 6. See Fig. 5 for explanation.

stigma (component 1), sole (component 2), middorsal stripe width (component 1), tibia (component 1), thoracic color (component 1), and hindwing fenestration (component 1). Character coefficients on the third component revealed that color variation (frons, clypeus, labium, middorsal stripe, and prothoracic leg color) was mostly responsible for separating the groups; the ankle cell number was the only measured character with high value. The first three components accounted for 28%, 14%, and 8%, respectively, or a total of 50% of the variation. Components 4 through 18 accounted for the remaining 50%, but each component averaged 3.3% (range = 6% to 1%).

The scattergrams for males show *luctuosa* and *odiosa* to form a single cluster, although individuals of *odiosa* approach Colorado River individuals in appearance. The third component (Fig. 6) was minimally useful in further delineating these groups. Three males were misclassified: one *odiosa* clustered with the Colorado River forms (components 1 and 2); another *odiosa* clustered correctly in relation to components 1 and 2, but was greatly separated by component 3; a single Colorado River individual clustered with the latter *odiosa* specimen, forming a separate subgroup. The last two males were juvenile, which probably accounts for their aberrant location in the scattergram. Since the third component represents primarily color variation, color and maculation of these juveniles are probably responsible for their misclassification. Blue pruinosity on the juvenile Colorado River morph had not obscured the yellow middorsal stripe and brown and yellow sides of the synthorax. In addition, both juveniles had an olive-brown frons and lighter facial colors, instead of a black frons and darker facial colors common to all other individuals. The important factor loadings (Table 2) for these characters on component 3 probably contributed to their misclassification. The thoracic color coefficient was also relatively high on components 1 and 2, and it probably contributed to the odd placement of the juvenile Colorado River male, since it was the only Colorado River morph lacking the blue pruinosity on the sides of the pterothorax. Of the 116 males, 2% were misclassified according to the author's subjective treatment of the groups. The *odiosa* and *luctuosa* phenotypes are not phenotypically distinct enough to warrant their status as separate taxa.

Results for the females were similar to those for the males, except that the 13 Colorado River females did not separate as clearly. Factor loadings for the first two components (Table 2) show forewing fenestration, as in the males, to be least important in separating the phenotypes. All other characters were important in explaining the variation; however, higher coefficients ($-.300 > \alpha > .300$) prevailed for continuous characters (hindwing, pterostigma, femur, tibia, and abdomen 5) on component 1, while the same range of values predominated for coded character coefficients (wingtip length, frons, clypeus, middorsal stripe color, and pterothoracic leg color) for component 2. Only one measured character (sole) resulted in a high value on component 2. Because body color patterns in female *L. luctuosa* vary more than in mature males, it is logical to expect greater importance for coded color characters. The southwestern desert forms are lighter than their eastern counterparts. The other components were not useful in further delineating between

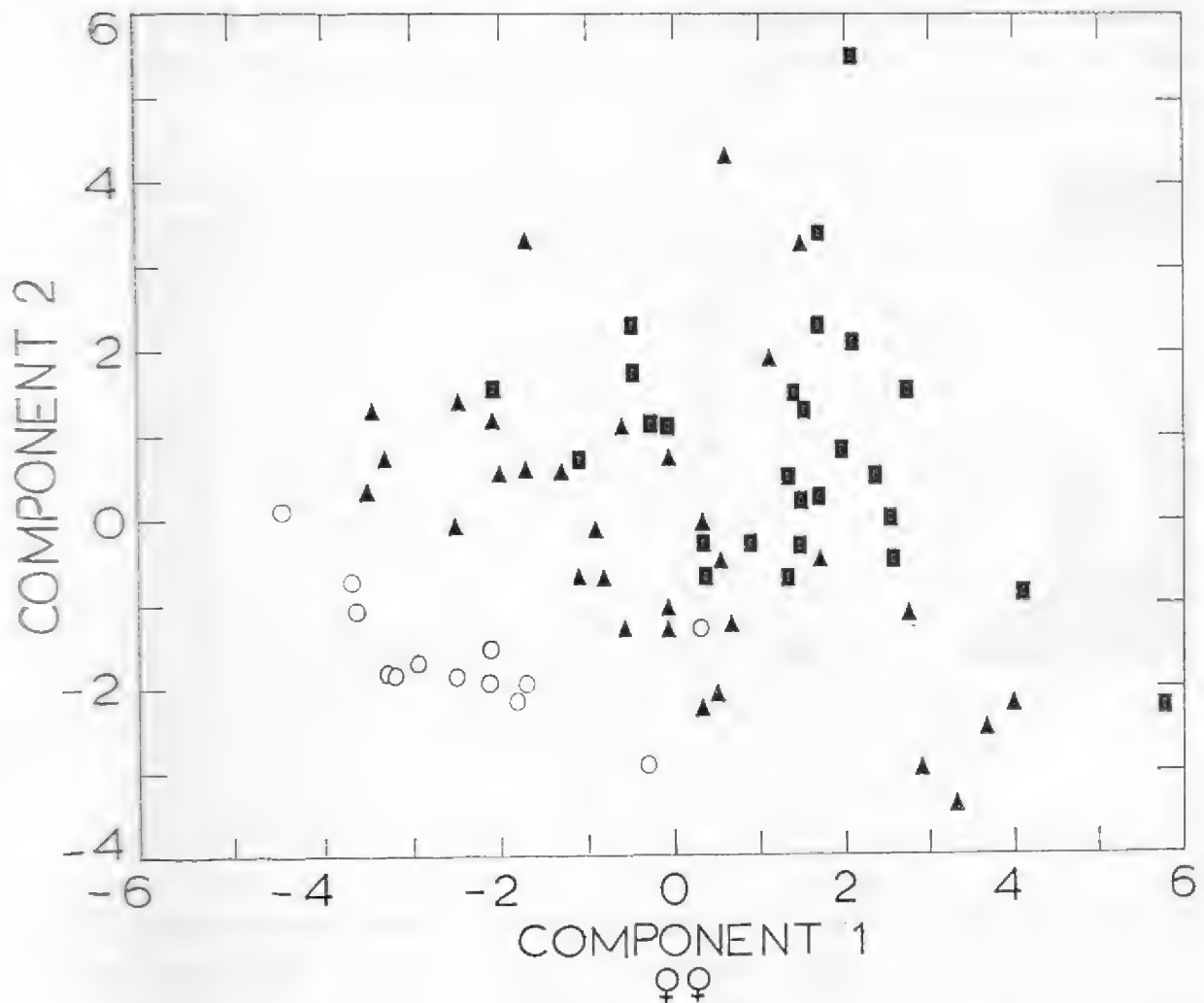


FIG. 7. Scattergram of principal component scores for females. See FIG. 5 and 6 for explanation of symbols.

groups. The first and second components accounted for a total of 45% of the variation. Components 3 through 17 accounted for the remaining 55%, with each component averaging 3.4% (range = 10% to 1%) of the variation.

As in males, there is no clear separation between *odiosa* and *luctuosa* morphs. Of the 13 desert OTU's, one clustered with *odiosa* (Fig. 7). This specimen was the only juvenile female of the group (lacking most of the violaceous pruinosity on thorax and abdomen), but otherwise its color and maculation did not differ appreciably from the other 12. However, it and one other female were the smallest specimens of the group. The other female was mature, but its location in Figure 7 ($PC_1 = -0.367$, $PC_2 = -0.288$) places it near the juvenile. Phenetic gaps between the desert and *odiosa-luctuosa* phenotypes are not as great as for the males.

Step-wise Discriminant Analysis.—Of the 10 or 11 measured characters used, only four, with two exceptions, repeatedly emerged with high

TABLE 3. Classification of Assigned OTU's into Respective Groups with 10 and 11 Characters by Step-wise Discriminant Analysis—Males (M) and Females (F).

Number of Characters		Morphs	luctuosa	odiosa	Colo. Riv.	Total	Number Misclas- sified	Percent Misclas- sified
M	10	luctuosa	20	5	0	25	5	20
		odiosa	7	16	2	25	9	36
		Colo. Riv.	1	0	24	25	1	4
M	11	luctuosa	24	1	0	25	1	4
		odiosa	5	19	1	25	6	24
		Colo. Riv.	0	1	24	25	1	4
F	10	luctuosa	20	4	1	25	5	20
		odiosa	8	22	2	32	10	31
		Colo. Riv.	1	1	11	13	2	15
F	11	luctuosa	23	2	0	25	2	8
		odiosa	6	24	2	32	8	25
		Colo. Riv.	0	1	12	13	1	7

F-values. Highest of the F-values was for hindwing fenestration ($14.36 < F < 706.18$), followed by middorsal stripe width ($9.16 < F < 58.82$), then tibia ($8.33 < F < 37.46$), and finally sole length ($0.90 < F < 28.17$). Abdominal segment length ($F = 4.02$) and femur length ($F = 7.21$) were the only other characters selected in the first three steps.

Classification of assigned specimens into their respective groups showed odiosa morphs to be more frequently misclassified (up to 36%) than the other two groups. This shows the odiosa sample to be a more heterogeneous group, a conclusion supported by the high variability of hindwing fenestration. Table 3 shows that most of the misclassified odiosa were placed with luctuosa.

Linear Discriminant Analysis.—Principal component analysis revealed insignificant differences between odiosa and luctuosa, so these forms were treated as one group in this analysis. The four characters selected by step-wise discriminant analysis were used to classify unassigned *L. luctuosa*. A histogram of z-values for males, using the following four discriminant function coefficients, is shown in Fig. 8: sole = .036, hindwing fenestration = -.006, middorsal thoracic stripe width = .116, and tibia length = -.025. The mean z-value for the odiosa-luctuosa group was .208, and for the Colorado River males, .105. While the mean of the two was .156, it could not be used to separate the groups, because four odiosa had values less than .156; but a critical z-value of

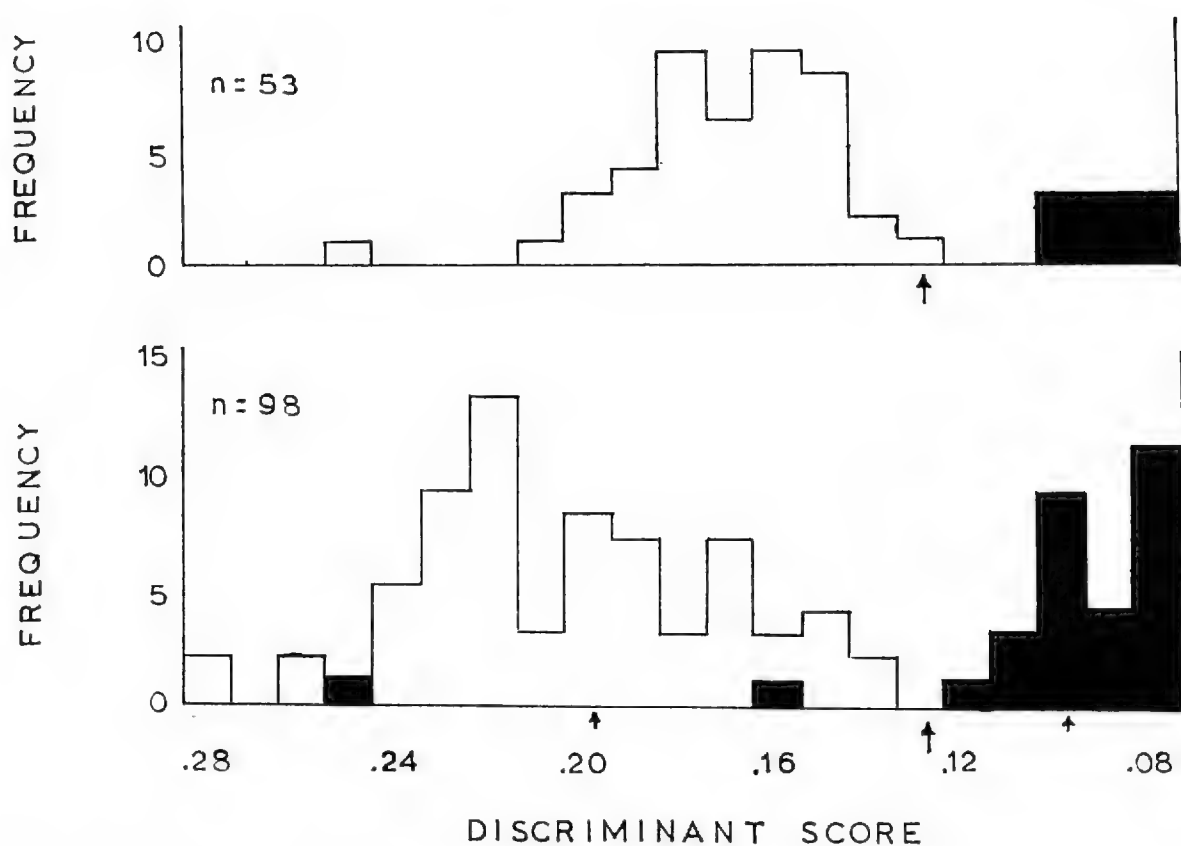


FIG. 8. Histograms of discriminant scores for reference males (below) and unassigned males (above). White = *luctuosa* (reference) and *odiosa* (unassigned), black = Colorado River morph. Means for all groups are marked by small arrows; larger medial arrows indicate critical z-value.

.130 segregated the two reference samples. Therefore, OTU's with a $z > .130$ are classified as *odiosa-luctuosa* phenotypes, while OTU's with $z < .130$ are classified as Colorado River morphs. Two misclassified Colorado River morphs had scores of .255 and .164 (Fig. 8). The former specimen was the juvenile previously misclassified by principal component analysis. The second male was similar to the others: no reason for its misclassification is apparent. As with principal component analysis, 2% of the reference males were misclassified.

Fifty-three unassigned male *L. luctuosa* comprising mostly of *odiosa* phenotypes from Texas, New Mexico, Arizona, California (Central Valley), as well as nine Colorado River phenotypes from Yuma and Phoenix, were plotted using discriminant constants for reference males (Fig. 8). All but one of the specimens were classified correctly, though the *odiosa* phenotypes are heavily skewed to the right of the reference males. The *odiosa* sample lacked any eastern *luctuosa* phenotypes and indicates that the *odiosa* morphs are intermediate between the end groups but are more similar to nominate *L. luctuosa* than to the Colorado River phenotype. Only one *odiosa* morph had a z-value falling within the critical range and could not be classified with certainty.

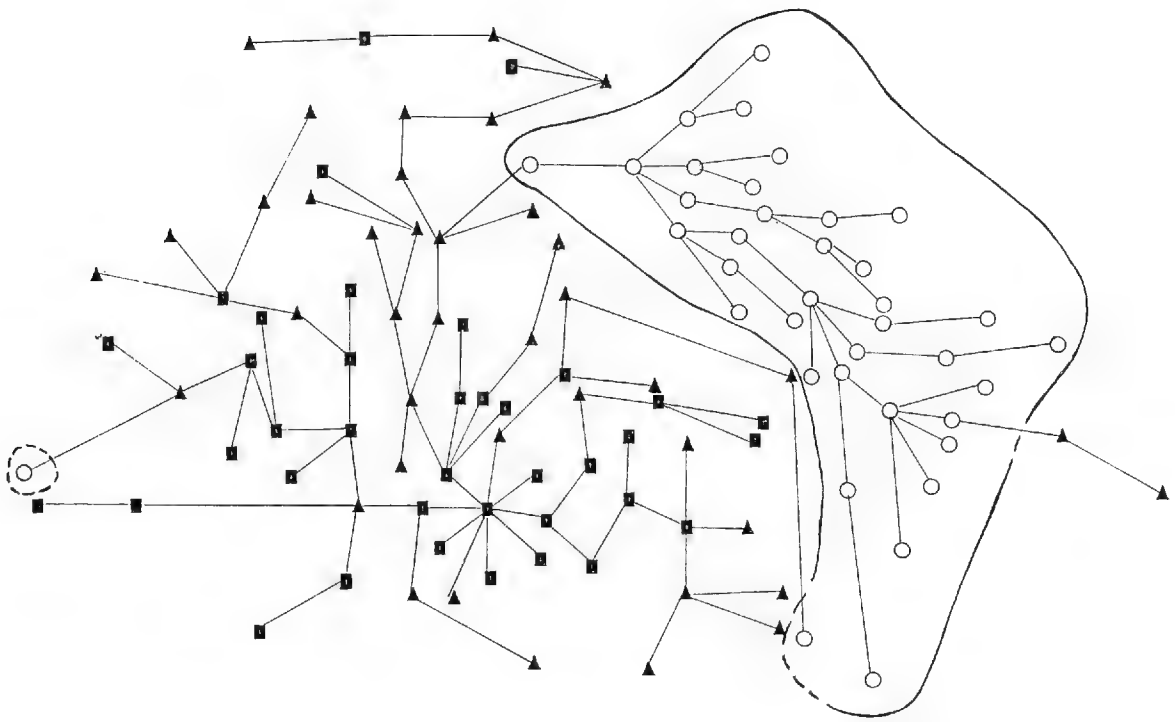


FIG. 9. Minimally connected network (Primnet) for males ($n = 116$) based on taxonomic distance. Open circles = Colorado River morphs, triangles = *odiosa*, squares = *luctuosa*. Connecting lines between OTU's indicate phenetic similarity, placement of non-connected OTU's is arbitrary and indicates no phenetic relationship. Superimposed solid curvilinear lines indicate *a priori* clusterings of Colorado River morphs, dotted lines indicate those misclassified. See text for further explanation.

Linear discriminant values for females were not useful in separating Colorado River forms from *odiosa-luctuosa*. Only 13 Colorado River females were available for the study, and four of them were classified as intermediate between *odiosa-luctuosa* phenotypes. Two others fall on the critical z -value (between $-.39$ and $-.41$), and the remaining seven form one end group. Of the 70 females, 8% were misclassified, but 46% of the Colorado River females were misclassified, compared to 5% for males.

Numerical Taxonomic Results.—Primnets for males and females are shown in Figures 9 and 10. The curvilinear lines superimposed over the Colorado River morphs (open circles) indicate the author's subjective classification of this group; dotted lines indicate misclassifications in the Primnet. The results are largely concordant with principal component and linear discriminant analysis. Little distinction was made between *odiosa* and *luctuosa* males (Fig. 9); there were several connections between the two. The Colorado River morphs are on a separate sidebranch, with two *odiosa* OTU's connected to it. On the other hand, two Colorado River morphs are connected to *odiosa* OTU's in remote

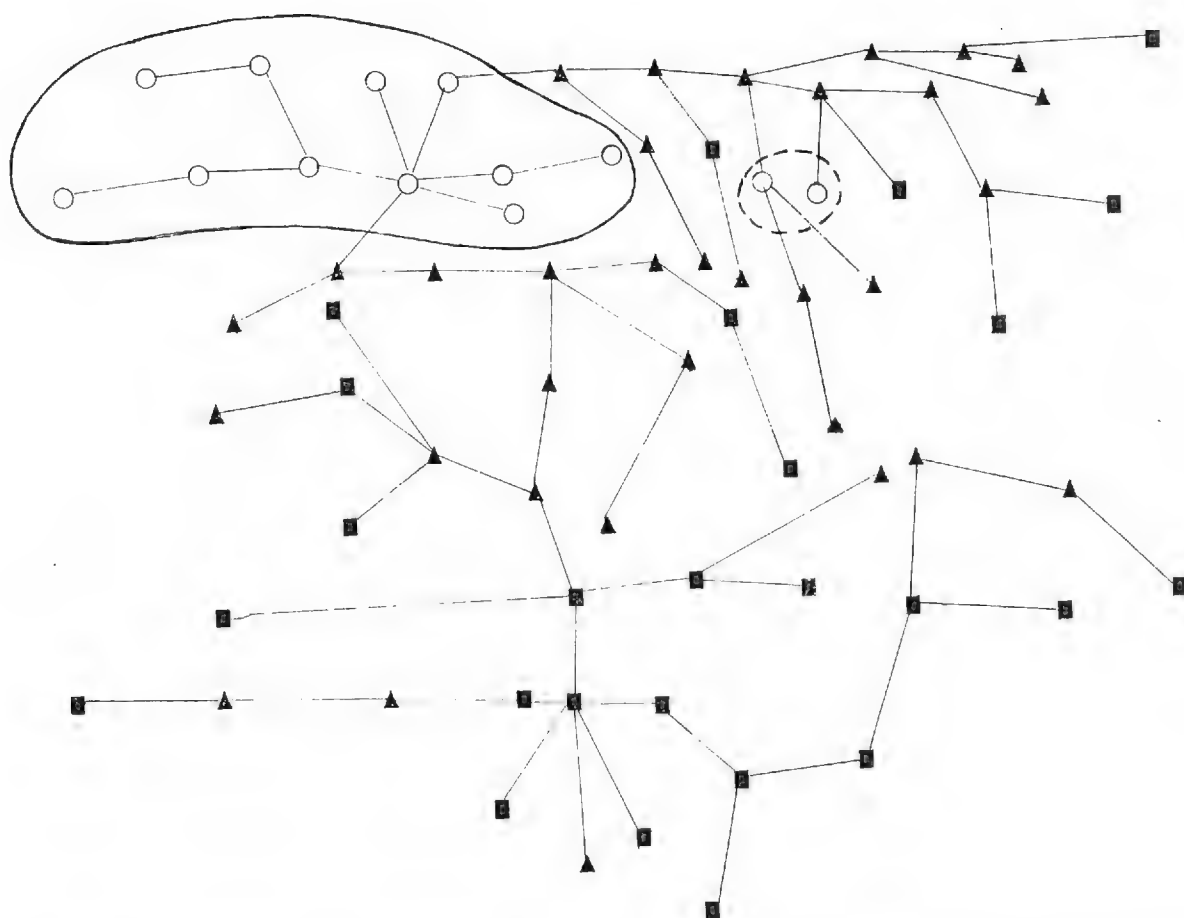


FIG. 10. Minimally connected network (Primnet) for females ($n = 70$) based on taxonomic distance. Symbols and designations as for Figure 9. See text for further explanation.

parts of the network. One of these is the same juvenile specimen misclassified by principal component and linear discriminant analysis. The other specimen was not misclassified by any of the previous methods, and the reason for its misclassification is unclear. The taxonomic distance between OTU's is relatively uniform, with a range of 0.38 to 1.96, with 104 OTU's having values less than 1.00. If *odiosa* and *luctuosa* morphs are considered the same, only two Colorado River morphs out of 116 OTU's (2%) were misclassified according to *a priori* treatment by the author.

Classification of the females (Fig. 10) was similar to preceding results but was much more confused. The Colorado River phenotypes do not form a separate sidebranch, but are linked to *odiosa* OTU's in different parts of the network. Two females of the Colorado River morph are connected only to *odiosa* phenotypes, the same two specimens misclassified by principal component and linear discriminant analysis. Taxonomic distances range from 0.33 to 2.10, but 65 of the OTU's had distances less than 1.00. In both Primnets, no Colorado River phenotypes are connected to any eastern *luctuosa* morphs.

As with the previous programs, phenetic gaps between Colorado River morphs are obvious in males, but not in females. Most misclassified OTU's were identical in all methods, which indicates discrepancies in size and coloration due to juvenile condition to be the most likely causes of misclassification.

DISCUSSION

The author subjectively recognized three distinct morphs of *Libellula luctuosa*, with phenotypic intermediates occurring in the central United States. A definite phenetic gap was observed only between the highly pruinose desert populations and the less pruinose luctuosa-odiosa phenotypes. The lack of intermediate forms may be due in part to inadequate collecting, but is mostly a result of the absence of specimens from the Tehachapi Mountains of California and from the eastern edge of the Sonoran Desert in Arizona.

Results of the various analyses show a high degree of concordance in the classification of intraspecific forms. The *a priori* distinctions between odiosa and luctuosa are not salient and the names do not warrant separate taxonomic rank. The only recognizable difference between the two is the degree of clearing in the hindwing bands, but an adequate sampling of populations of the odiosa morph shows this condition to be highly variable. Within the same deme are found individuals with little or no clearing (Fig. 4a) and with hindwing bands approaching dark rings (Fig. 4d). The pruinosity patterns of male odiosa-luctuosa morphs are identical, confined largely to the mesepisternum and abdomen (Fig. 3c). The middorsal thoracic carina and mesopleural regions are always black, and the rest of the synthorax is dark brown.

The California populations of odiosa, although geographically isolated from their midwestern counterparts by the Great Basin, are not phenotypically distinct. It seems likely that the allopatric populations of odiosa at one time shared a common gene pool instead of the two forms having arisen independently of one another. Specimens from the Pacific Northwest are rare, and the two individuals from British Columbia are typical of eastern luctuosa in appearance. While this suggests that *L. luctuosa* may range across southern Canada, no specimens are known from Alberta or Saskatchewan.

No captures of *L. luctuosa* are known from Nevada (La Rivers, 1940, 1941), Utah (Brown, 1934; Larsen, 1952; Musser, 1961), Wyoming, South Dakota, or Montana (Bick and Hornuff, 1972, 1974), where its absence may be due to adverse environmental effects of temperature, precipitation, or altitude. The Colorado River forms are allopatric with

the odiosa morph, and no intermediate forms are known; but this may be due to scanty collecting in the Tehachapi Mountains and the eastern Sonoran Desert. Before the drying of the Southwest during the later Tertiary (Axelrod, 1967; Antevs, 1955), forms similar to odiosa may have inhabited the area now occupied by the desert forms. Ancestral desert forms, then, may have at one time provided a continuous distribution of odiosa morphs from California to the central United States.

Libellula luctuosa has a Nearctic distribution and does not penetrate Neotropical regions of Mexico (Calvert, 1906) or peninsular Florida (Byers, 1930). Its absence from the Neotropics and the Great Basin is probably not due to physical barriers, since *L. luctuosa* is a vagile species which regularly frequents temporary bodies of water in the Southwest.

The frequency for extensive brown wingtips in females increases from east to west, so that all Colorado River females possess the condition shown in Figures 3e and 3f. In contrast to these, 29 of 110 (26%) odiosa females west of the Mississippi River and two of 30 (6.6%) *L. luctuosa* east of the Mississippi showed wingtip coloration comparable to the desert females. The sole and metathoracic tibia length of the Colorado River morphs and eastern *L. luctuosa* show an inverse relationship in size. The hindwing width of the Colorado River forms is less than that of the eastern forms, but the metathoracic tibiae are longer in the desert forms. A t-test performed on the means of both characters for both sexes was significant at the 0.05 level. The reason for this variation is unknown, but similar patterns of geographic variation have been reported by Alpatov (1929) for honeybees and by Rensch (1943) for carabid beetles.

Thirteen of 188 OTU's (7%) were misclassified by one or more methods of analysis. Eight of those were females. Of the 13, only three were misclassified by all methods—a juvenile male Colorado River morph and two female Colorado River morphs. The male differed significantly from the others in its group because pruinosity had not yet obscured its thoracic pattern. The females were probably misclassified due to age and size differences. One was juvenile, the only one of its group in this condition, and both were relatively small—their hindwing lengths were 37 mm, compared to a mean of 39.3 mm for the entire group. One of the other males misclassified by principal component analysis was also juvenile, but no other anomalies were observed for the remaining nine specimens, and the reasons for their misclassification remain obscure.

Pruinosity patterns are responsible for the greater distinctness of male than female desert forms. The presence of pruinosity is reflected

in three male characters: thoracic coloration, width of middorsal stripe, and prothoracic leg color. The thoracic coloration in females is brown and yellow with only a violaceous pruinose tint (not present in *odiosaluctuosa* phenotypes) covering the usually dark brown patterns of the thorax and abdomen (Fig. 3b). The yellow middorsal stripe is always present in all females, and the prothoracic leg color is yellow. The extensive pruinose condition of the males and, to a lesser extent, females, is probably of some adaptive significance. Unfortunately, the chemical nature and biological significance of pruinosity are unknown. Johnson (1973) speculates that "it is a process of nitrogen elimination acted on by sexual selection producing mate recognition clues." There is strong evidence that pruinosity does provide mate recognition cues (Jacobs, 1955; Johnson, 1962a, 1962b), but it is also present on old females of some species (Longfield, 1960; personal observations), so its pronounced condition on the southwestern desert forms may also indicate a physiological function. The southwestern morphs conform, as do many other invertebrates, to Gloger's rule, which states that races from cool areas are more heavily pigmented than those from warm areas. There is no undisputed explanation for this phenomenon, but solar reflectance by pale coloration may be one possibility (Bodenheimer, 1954).

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Westfall, Jr., University of Florida, Gainesville; and H. E. Evans of the Museum of Comparative Zoology, Cambridge, for the loan of the types of *L. odiosa*. I wish to express my sincere thanks and appreciation for their cooperation. D. R. Paulson of the University of Washington and K. Tennessen of the University of Florida kindly made available material from their private collections.

The photographs were executed by Herman G. Real; and I especially wish to thank my wife, Jo, who typed the manuscript and aided me with its completion.

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SCIENTIFIC NOTE

A Female Specimen of *Acanthocinus* (*Canonura*) *leechi*.—In 1956 (Ann. Entomol. Soc. Amer., 49:228), Lawrence S. Dillon described a new species of *Canonura*, *C. leechi*, from a single male specimen from Jerome, Yavapai County, Arizona. The author recently collected a female in the Hualapai Mountains, Mojave County, Arizona, at black light, in pinyon pine juniper forest, at approximately 5,300 feet. Since the female has been unknown until this time, a brief description follows.

Form moderately robust, similar to the male. Pronotum at sides beneath lateral tubercles deeply punctate, lacking fuscous maculae. Antennae twice as long as body, segments with the following ratio: 1.0; .2; 1.4; 1.3; 1.2; 1.2; 1.1; 1.1; 1; 1; 1. Abdomen with fifth sternite prolonged, slightly shorter than sternites 2 through 4 combined, ovipositor strongly produced, extending 5 mm beyond tips of elytra. Length: 16 mm, not including ovipositor.

This insect is uniformly speckled with numerous small dark spots. These spots are much more discernable due to the absence of well defined hoary pubescence which is so pronounced in *A. spectabilis* (LeConte) and *A. princeps* (Walker). *A. leechi* also differs from *A. princeps* by the absence of fulvous markings on the elytra and by the color of the pubescent maculae of the pronotum. —A. E. LEWIS, 1360 Paseo Redondo, Burbank, CA 91501.

Notes on North American Nepidae

(Hemiptera: Heteroptera)

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In connection with continuing studies aimed at an eventual comprehensive treatment of the zoogeography and systematics of North and Middle American Aquatic Hemiptera, numerous collections and investigations have been made resulting in data that are needed by other workers. This paper is one of a series of short notes presenting selected data on systematics and distributions.

In 1930, Hungerford considered it remarkable that a new *Ranatra* would be found in the United States. His *R. texana* Hungerford is now known to occur also in Middle America (see below) with the Texas records being the northernmost extension of its range. With much more comprehensive data available to us now, it is perhaps more remarkable that there is an apparent endemic relict new species of *Ranatra* in Arizona, which I describe below.

The description follows roughly the format of Lansbury (1972) rather than Hungerford (1922), in order to preserve a continuity of style with the latest major reviser in the group. Lansbury's lora of the head is equivalent to Hungerford's jugum. All measurements given in units have 60 units = 1 mm. Types held in the Polhemus Collection are irrevocably committed to later placement in a designated type repository. All material upon which this paper is based is in the Polhemus Collection unless otherwise noted. I am indebted to A. S. Menke, U. S. National Museum (USNM) and J. Donahue, Los Angeles County Museum of Natural History (LACM) for their assistance.

***Ranatra montezuma*, n. sp.**

Male.—body length 21–24 mm, respiratory siphon 13–16 mm; Female: body length 25–28 mm, respiratory siphon 19–21 mm.

Vertex clearly raised above eyes, smoothly rounded. Eye width less than interocular space (4/4.5). Clypeus and lora about equally high. Elongations of second and third antennal segments equal.

Anterior lobe and posterior lobe unicolorous. Anterior lobe almost twice as long as posterior lobe (7/4), humeral width about one-fourth greater than anterior width (13/10.5). Prothorax without strong median keel or sulcus. Scutellum about twice as long as broad (8.3/4.5). The median finger-like posterior projection

* Contribution from the Department of Environmental, Population and Organismic Biology, University of Colorado, Boulder, 80302 and Martin Marietta Corp. Denver 80201.

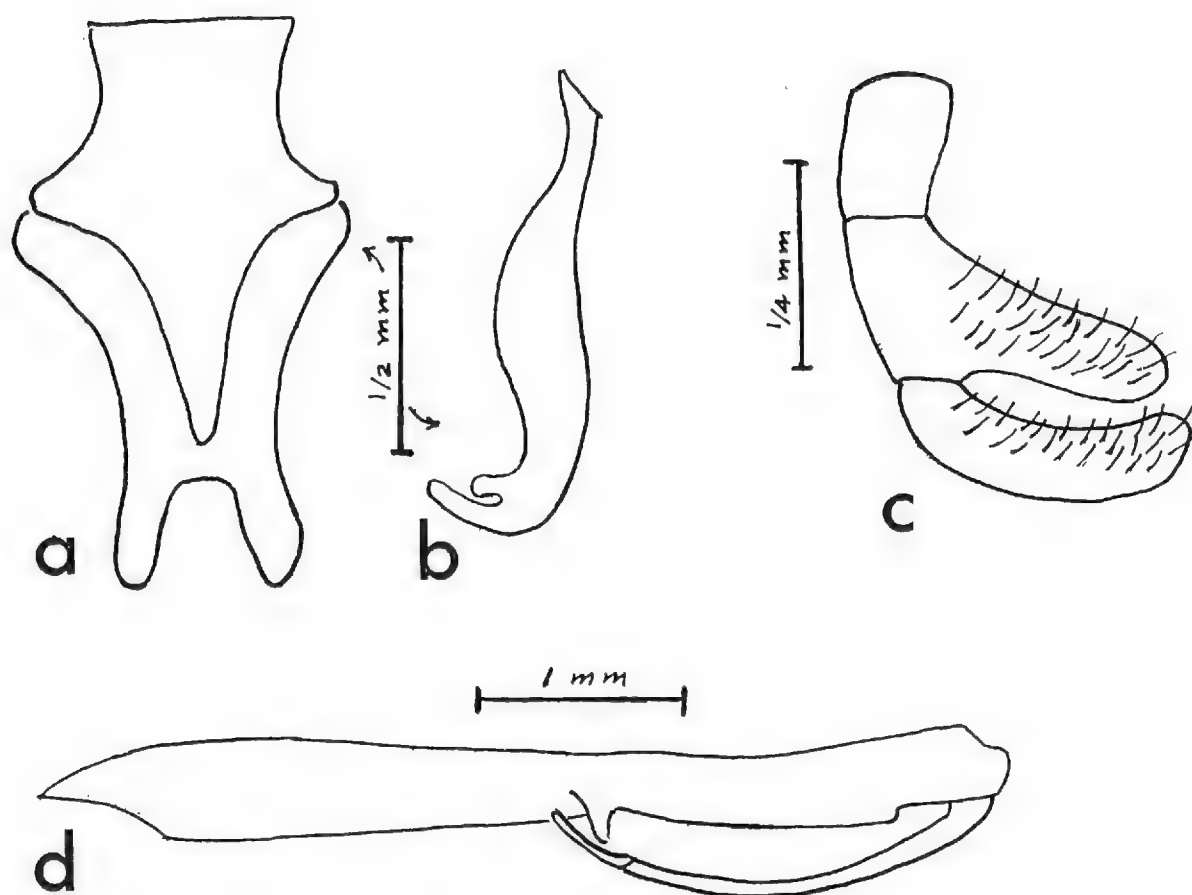


FIG. 1. *Ranatra montezuma* n. sp., male. a. metasternum. b. left paramere. c. antenna. d. foreleg.

of the metasternum not elongated, reaching only to middle of hind coxae, slightly raised medially (Fig. 1).

Fore femur with stout median tooth and small apical tooth. Posterior femur slightly longer than intermediate femur, reaching only to basal fifth of abdominal sternite 5. Tips of posterior tarsi not exceeding middle of siphon in male, basal third of siphon in female.

Female operculum barely exceeding connexivum. Male paramere with a distinct tooth on inner margin.

Material examined: Holotype (♂), Allotype (♀), and paratypes 21 ♂♂, 11 ♀♀, ARIZONA, YAVAPAI Co., NR. RIMROCK, MONTEZUMA WELL, CL695, III-27-'75, J. T. Polhemus (JTP Coll.). Paratypes, 42 ♂♂, 33 ♀♀, same location, June 19, 1968, A. S. Menke and O. Flint (USNM). Other specimens, not paratypes, 8 ♂♂, 4 ♀♀, same location, A. S. Menke and L. Stange, April 1, 1958 (LACM).

Discussion: *Ranatra montezuma* belongs to the same group of species as *brevicollis* Montandon, *fusca* Palisot Beauvoir and *quadridentata* Stal, which occur in the same region, but is smaller than any of them. In this group, the last abdominal segment in the male does not extend ventrally to embrace the distal part of the operculum, and the respiratory siphon of the females is not as long as the body. Of these species, *montezuma* most closely resembles *brevicollis* in the short appendages and general facies, but differs from the latter in having a relatively

longer anterior lobe, second antennal segment with digitate process subequal to third (as opposed to half as long in *brevicollis*), and having a much stouter male paramere of different shape. *R. fusca* has a longer siphon, the lora are less elevated, and the eyes are larger and more transverse than *montezuma*. *R. quadridentata* has a differently shaped paramere (see Hungerford 1922) and the tylus is not as prominent, appearing much shorter than in *montezuma*.

RANATRA TEXANA HUNGERFORD

Ranatra texana Hungerford, 1930. Can. Entomol. 62:217 (type, ♂, Bee Co, Texas, in Snow Entomological Museum, Lawrence, Kansas)

Material examined: UNITED STATES. *Texas*: 3 ♂ ♂, 4 ♀ ♀, Christoval, Conchos River, CL1113, V-9-'64, J. T. Polhemus; 3 ♂ ♂, 1 ♀, Ottine, CL396, VIII-6-'67, J. T. Polhemus. MEXICO. *Chiapas*: 1 ♀, Puente La Flor, CL1247, XII-19-'69, J. T. Polhemus. *Oaxaca*: 1 ♂, Juchitan, CL1244, XII-18-'69, J. T. Polhemus. *San Luis Potosí*: 1 ♂, 35 km. N. Tamazunchale, CL1241, XII-16-'69, J. T. Polhemus. *Veracruz*: 1 ♂, W. of Veracruz, CL1335, I-16-'70, J. T. Polhemus. GUATEMALA. 3 ♂ ♂, 4 ♀ ♀, 10 mi. N. Ascuncion Mita, CL1313, I-10-'70, J. T. Polhemus; 2 ♂ ♂, 1 ♀, Puerto San Jose, CL1250, XII-20-'69, J. T. Polhemus.

RANATRA SPATULATA KUITERT

Ranatra spatulata Kuitert, 1949. J. Kansas Entomol. Soc. 22:32 (Type, ♂, listed as being from "Key West, Florida, May 8, 1919," in U. S. National Museum.)

Kuitert (1949) gives the type locality as Key West as noted above, and further notes that the specimen is from the Frank Lutz Collection and is in the American Museum of Natural History. In fact, the specimen is from the J. C. Lutz Collection of Philadelphia, now in the USNM, where I studied the type.

Over the years I have become increasingly suspicious of the validity of the locality label on this type, the label being photographically reproduced from a typed original, probably by Lutz. In 1947 the assiduous collector Raymond Beamer made a trip to the Keys to try for *Ranatra* (Hungerford 1958), but was unsuccessful. Later I went to the Keys for the same purpose, and determined that the only permanent freshwater habitat there is a pond on Big Pine Key which I worked without finding any *Ranatra*. Finally, I studied the type in the USNM, and found that it apparently is not allied to the American fauna, having the metasternum and male parameres of a form typical of Old World species, but not seen in any New World species.

Having just collaborated with Dr. Ivor Lansbury of Oxford in working out the differences in the Old and New World *Ranatra*, I asked him to borrow the type and give me an opinion on this species. (See

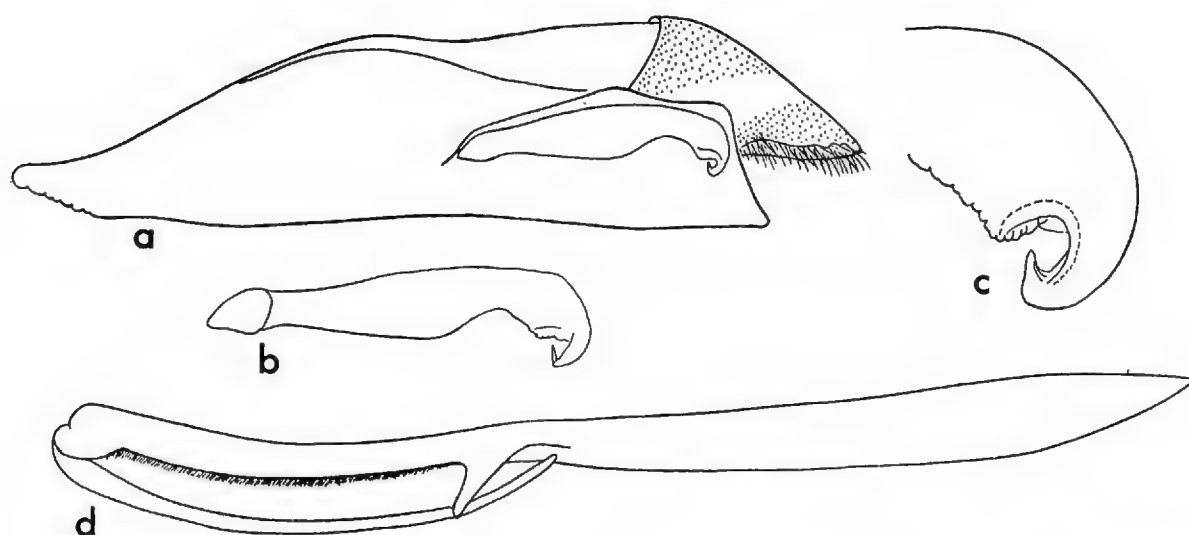


FIG. 2. *Ranatra spatulata* Kuitert. a. genital capsule. b. paramere, slightly enlarged. c. paramere, distal portion. d. foreleg.

Lansbury 1974 for a discussion of Old and New World *Ranatra*.) Dr. Lansbury very kindly obliged, and graciously offered the use of his sketch figures (Fig. 2) and comments, which are given here in part:

"I have now examined the type of *Ranatra spatulata* Kuitert and find that it is an African species which has been erroneously labelled, possibly by Frank Lutz. As far as I can discover . . . *spatulata* is a species of the *grandocula* Bergroth group. Comparison of the parameres shows a remarkable similarity with *R. capensis congoensis* Poisson, but the fore leg of the latter is quite different from that of *spatulata* and is quite similar to *grandocula*s.l. The metasternal plaque is very similar to *congoensis*. As a matter of interest, the type of *spatulata* does not have its front legs attached to the body, they are stuck on a piece of card (Hungerford det label) so the possibility exists that they are not the right legs at all!! When Kuitert described the species he partially removed the male genital capsule to see the parameres, in doing so, he somehow damaged the internal genitalia, all that is left is the bridge and lateral arms, the lamina ventralis and associated structures have all been removed, consequently I was not able to make as full a study as I would have normally done in these circumstances.

I am sorry not to be more specific about the real identity of *spatulata*. I can however assure you that it is not a North American species or an Oriental one."

As it seems certain that *Ranatra spatulata* is not of American origin, it should be stricken from the U. S. list and carried instead as an African species, with its exact origin unfortunately not known.

CURICTA PRONOTATA KUITERT

Curicta pronotata Kuitert, 1949. J. Kansas Entomol. Soc. 22:66 (type, ♂, Huachuca Mts., Ariz., U. S. National Museum)

Vincent Roth rediscovered this species in northwestern Sonora and collected it in numbers in Canyon de Evans. Searches in other locali-

ties in upper Sonora and Arizona have not revealed other colonies. Previously known only from the type series of three males, it is new to Mexico. A good series reportedly collected in Canyon de Evans (Roth, *in litt.*) has not been seen by me, but I have some that he and I collected.

The female is of the same general facies as the male, but slightly larger; body length 25 mm, respiratory siphon 10 mm.

Material examined: MEXICO. *Sonora:* 2 ♂♂, 1 ♀, 6 nymphs, Canyon de Evans, Sierra de los Ajos, Pine-oak, N. end, 31°N-110°W, VI-1-'71, V. Roth; 1 ♂, Canyon de Evans, 17 mi. S. E. Cananea, CL570, III-30-'73, J. T. Polhemus.

CURICTA HOWARDI MONTANDON

Curicta howardi Montandon, 1910. Bull. Soc. Sci. Bucharest 18:181 (type, Victoria, Texas in U. S. National Museum).

Curicta drakei Hungerford, 1922. Kansas Univ. Sci. Bull., 14 (18):432.

This little species is widespread in southeastern Texas, and has been reported from Louisiana by Hungerford (1922) and Ellis (1952). I have found it in abundance only in Skull Creek (see below), but diligent collecting resulted in specimens from several other localities.

Material examined: Texas: 55 adults and nymphs, Rock Island Co., Nr. Altair, Skull Creek, CL392, VIII-6-'67, J. T. Polhemus; 1 ♂, 2 nymphs, Sheridan, CL394, VIII-6-'67, J. T. Polhemus; 1 ♂, 1 ♀, Ganado, CL451, VI-5-'69, J. T. Polhemus; 1 ♀, College Station, VI-1-'31, H. Mills; 1 ♂, Brazos Co., College Station, X-10-196?, J. Sweet.

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A new species of *Hermatobates*

(Hemiptera: Heteroptera)

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Hermatobates is a genus of rarely collected and little known marine insects. The first species, *H. haddoni* Carpenter was described in 1892. Several additional species were described subsequently (Coutière and Martin, 1901a, 1901b; China, 1956, 1957; Herring, 1965) and they were all assigned to the Gerridae although Matsuda (1960), in his review of the World Gerridae, excluded *Hermatobates* from that family. The status of this genus is thus still debatable; it will be discussed elsewhere (Andersen, Cheng & Polhemus, in preparation). A review of the relevant literature, with a list of the known species, their distributions and their biology, was published by Cheng (1976).

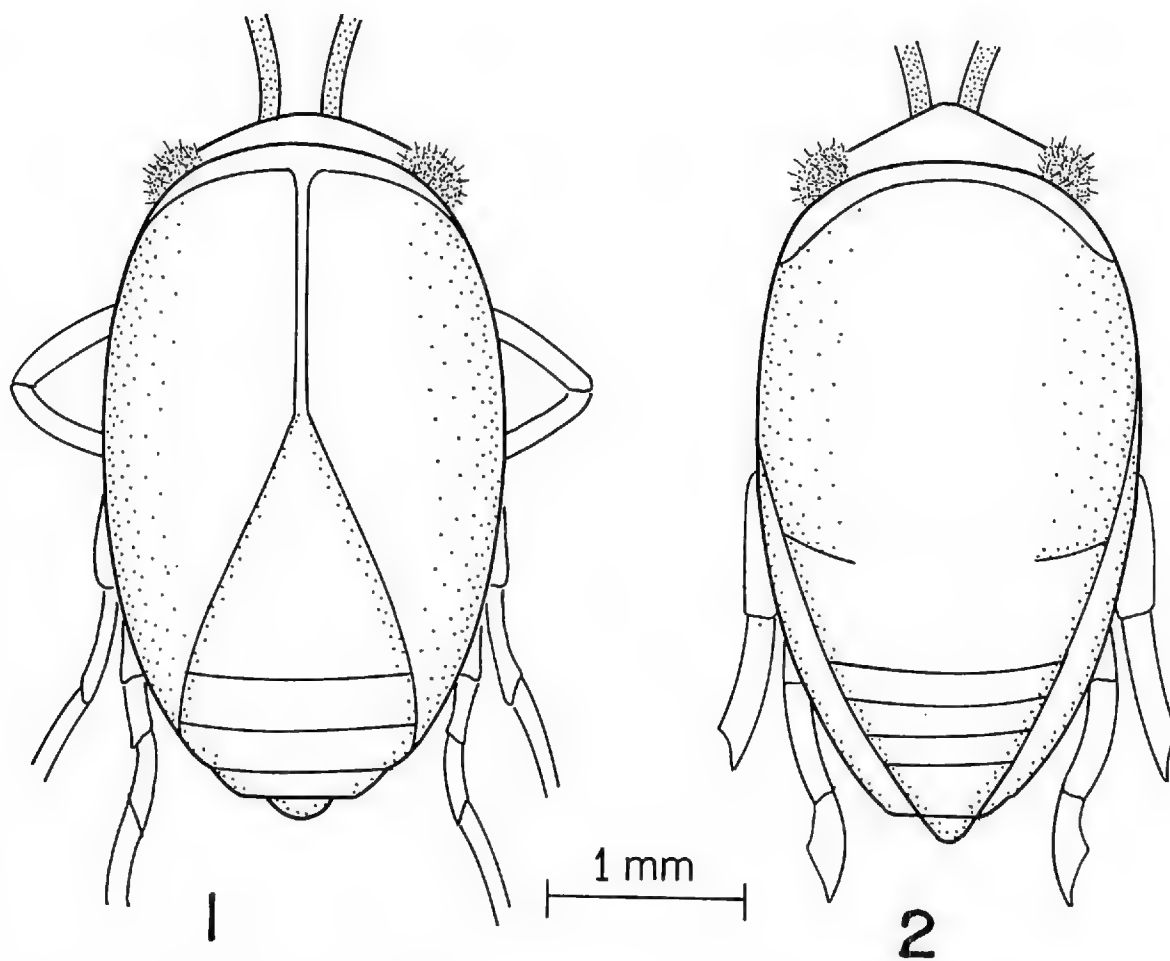
The specimens to be described in the present paper were collected off the west coast of Singapore; they were referred to briefly, without specific epithet, by Cheng (1966, 1976).

Hermatobates singaporensis new species

Holotype male.—(Figs. 2, 5 and 6). Apterous, dark brown dorsally, paler brown ventrally, without distinct markings. Body covered with short, velvety hairs. Legs with front femora greatly swollen, bearing thirteen small teeth between basal and distal tubercles; distal tubercle interlocks with tubercles borne at proximal end of front tibia which bears two oblique hair combs at distal end, with a broad groove between them (Fig. 3). Length, 3.5 mm; width, 2.0 mm; ratios of various antennal and leg lengths as follows (10 units = 1 mm): Antennae, 9: 9.5: 6: 6; front leg, 14: 14: 1: 1.5: 3; middle leg, 23: 12: 1: 6.5: 5; hind leg, 22.5: 13: 1: 6: 5.5 (there are 3 tarsal segments on each leg).

Allotype and paratype female.—Color pattern as in male; meso- and meta-nota differ from male in structure, with lobe-like extensions almost reaching apex of abdomen (Fig. 1). Front femora not swollen, bearing a row of small teeth on ventral edge but without pronounced tubercles (Fig. 4). Length, 3.6 mm; width 1.8–1.9 mm; ratios of various antennal and leg length as follows: Antenna, 7: 7: 5: 6; front leg, 11: 11: 1: 2: 3; middle leg, 18: 10: 1: 6: 5; hind leg, 18: 10: 1: 5.5: 5.5.

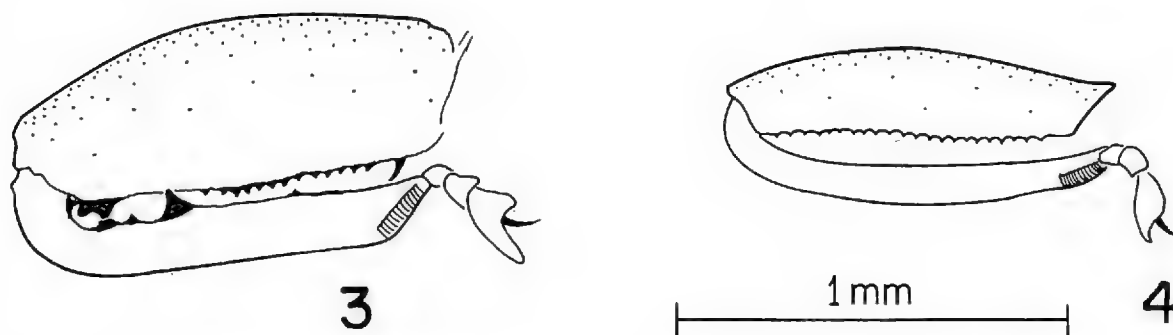
Type locality.—Holotype male, allotype and one female paratype from approximately 01° 17' N and 103° 52' E, about 5 km off the Siglap coast of Singapore near an offshore "Kelong" (fishing platform). The type specimens, one male and two females, known only from the type locality, were collected by dip netting from a small boat on 3 October, 1963. All three type specimens deposited at the U.S. National Museum, Washington, D.C.



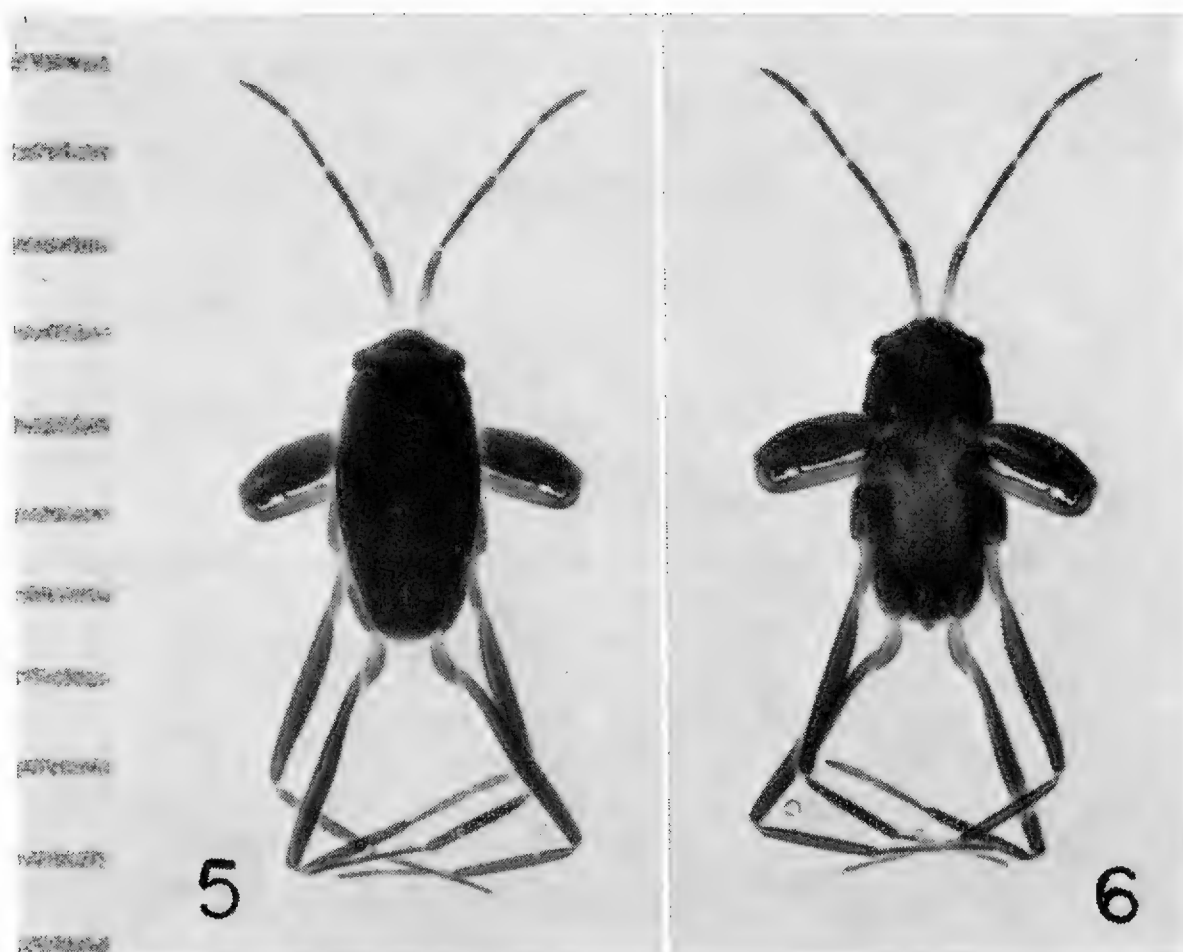
FIGS. 1-2. *Hermatobates singaporensis*. Fig. 1. Female. Fig. 2. Male.

Diagnosis.—This species can be distinguished from the 8 known species of *Hermatobates* by the arrangements of the teeth and tubercles on the male front femur and tibia. In this respect it appears to be closer to *H. weddi* China (1957), described from Monte Bello Island, and *H. marchei* (Coutière et Martin) (1901b) from the Philippines. However, the front femur of the former species has 14 small teeth between the basal and apical spurs and the latter has 12. There are 13 in *H. singaporensis*. The number and arrangement of tubercles on the front tibia are quite different in the three species.

I thank Dr. Jon L. Herring, U.S. Department of Agriculture, U.S. National Museum, Washington, D.C. for confirming this is a new species.



FIGS. 3-4. *Hermatobates singaporensis*. Fig. 3. Foreleg, male. Fig. 4. Foreleg, female.



FIGS. 5-6. *Hermatobates singaporensis*, holotype male (scale in mm). Fig. 5. Dorsal aspect. Fig. 6. Ventral aspect.

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SCIENTIFIC NOTE

Confirmation of the beach habitation of *Apatolestes actites* Philip and Steffan (Diptera: Tabanidae) on the California coast.—The original description of *Apatolestes actites* Philip and Steffan (tribe Pangoniini) was based on unique specimens of each sex that apparently were taken on or near two California beaches (1962, Pan-Pac. Entomol., 38: 41-43). The type locality of *A. actites* is Goleta Beach, near Santa Barbara, Santa Barbara Co., Calif. A third specimen that is present in the insect collection of the California Department of Health, Vector Control Section, Berkeley, was collected along the California coast at Montana de Oro State Park, San Luis Obispo Co. Its somewhat teneral condition suggests that it had emerged near the collection site.

One of us (VFL) collected a female *A. actites* on a sandy beach near Bolinas Point, Marin Co., on 16 June 1974. Further collections made there in 1974 yielded one male, one female, and about seven tabanid pupal skins; the latter were found among driftwood in the supralittoral zone. On 4 July 1975, a cool, overcast day, 30 flies (8 ♂, 22 ♀) were collected on this beach by five persons. Flies were prevalent below the high tide mark where clumps of seaweed were present. Numerous tabanid pupal skins and desiccated pupae (tribe Pangoniini) were found in, on, or protruding from sand above the high tide mark. Characteristics of the imago of *A. actites* (e.g., pilose body, bare eyes) were visible through the cuticle of the dead pupae. In the same area larvae of a species of Pangoniini were collected from sand approximately 8 to 10 cm below the surface. Dr. W. W. Middlekauff, Mr. T. Sukekane, and Mrs. S. Lane assisted in the July 4th collections.

Immatures also believed to be those of *A. actites* were collected at Manchester State Beach, Mendocino Co., California, on 14 and 27 July 1975. This record, if confirmed, would extend the northernmost distribution of *A. actites* approximately 140 km beyond Bolinas Point.

The foregoing observations support our belief that *A. actites* breeds on beaches along the California coast. We are attempting to rear larvae obtained from both the Marin and Mendocino Co. sites to conclusively associate them with pupae and adults.—V. F. LEE, *California Academy of Sciences, Golden Gate Park, San Francisco, Calif. 94118*; R. S. LANE, *California Department of Health, Vector Control Section, Berkeley, Calif. 94704*; and C. B. PHILIP, *California Academy of Sciences, San Francisco, Calif. 94118*.

A New Species of *Ischalia* from Southeastern China

(Coleoptera: Pyrochroidae)

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***Ischalia* (*Ischalia*) *chinensis* new species**

(Figures 1, 3, 4)

Description.—Length 4.9-5.8 mm. Body, exclusive of abdominal tergites, moderately covered with yellowish setae, those of elytra more erect than those associated with remainder of body.

Male.—Head sooty yellowish-brown unevenly suffused with dark brown to piceous markings; frontal aspect with shallow longitudinal groove mesally, between eyes. Antennae dark brownish to piceous basally, gradually becoming lighter toward apices. Terminal segment of maxillary palpus cup- or scoop-like, with outer surface convexly rounded and inner aspect concavely depressed.

Pronotum, scutellum, and ventral thorax sooty yellowish-brown unevenly suffused with brownish to piceous coloration. Pronotum irregularly concave in lateral view; gibbose anteriorly, sloping downward posteriorly for two-thirds of its length, then gradually upward toward hind margin. Anterior margin of pronotum (Fig. 1) weakly sinuate mesally, lateral margins evenly rounded from front posteriorly to the acute, weakly produced hind angles. Pronotal disk with prominent median carina which is produced posterad of hind margin, and 2 circular impressions or pits on either side of the carina: one near the carina and another near the postero-lateral margin. Mesepisterna widely separated. Legs sooty yellowish-brown to nearly piceous. Elytra elongate and covering abdomen, somewhat broader posteriorly with apices slightly separated along suture, surface densely and coarsely punctate to nearly reticulate; entirely pale yellowish-brown to yellowish-brown with pale brownish sutural margins. Sutural, humeral, lateral discal, and lateral carinae present with humeral carinae about one-third the length of lateral discal carinae, the later gradually curving inwardly toward the sutural carinae but terminating distant from them. Hind wing (Fig. 3) fully developed, pale yellowish in color.

Abdomen sooty yellowish-brown ventrally, unevenly suffused with brownish to piceous patches. Parameres ventrad of aedeagus, fused along entire length and broadly emarginate apically with 6 setae near apex, 3 on either side (Fig. 4).

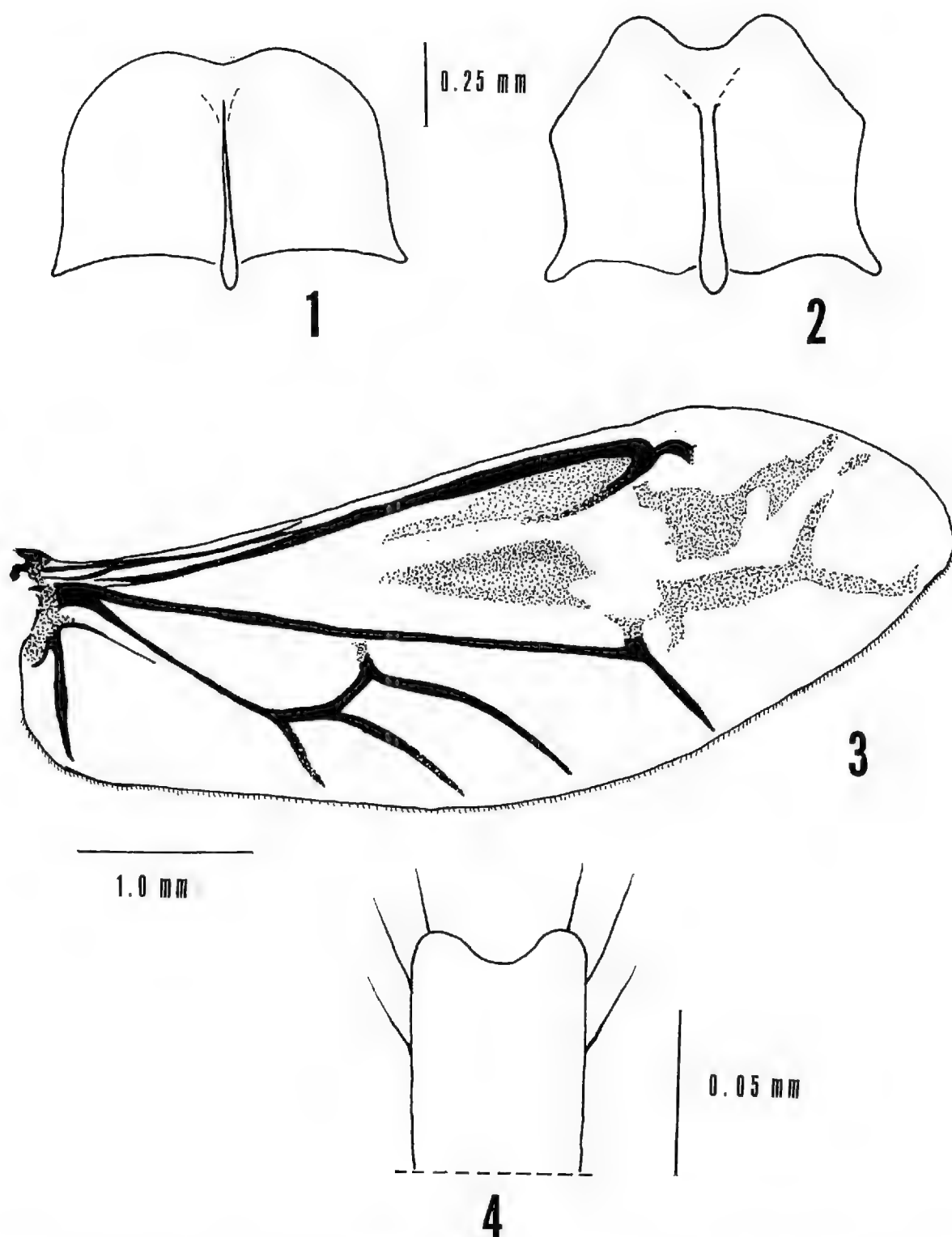
Female.—Differs from the male by having the terminal antennal segment excavated on outer surface, with the excavation densely setose.

TYPE INFORMATION: HOLOTYPE: (♂), HONG SAN, SE; KIANGSI, CHINA; 15 July 1936; L. Gressitt Collector; L. Gressitt Collection (CASC).

ALLOTYPE: (♀), same data as holotype except date: 16 July 1936 (CASC).

PARATYPE: (1 ♀), MOKANSAN, CHINA; CheKiang Pr.; 19 September 1927; Mrs. Dora E. Wright Collector (CASC).

DISTRIBUTION: As detailed above, southeastern China: KiangSi and CheKiang provinces.



FIGS. 1-4. Structures of *Ischalia*. Fig. 1. *I. chinensis* Young, pronotal outline, dorsal aspect. Fig. 2. *I. suturalis* Blair, pronotal outline, dorsal aspect. Figs. 3-4. *I. chinensis*. Fig. 3. Right hind wing of male. Fig. 4. Distal portion of fused parameres, dorsal aspect.

REMARKS: The presence of widely separated mesepisterna places *I. chinensis* in the subgenus *Ischalia* as redefined by Paulus (1971).

This species comes closest to the description provided by Blair (1912) for his *suturalis* of Assam, India. Through the kindness of C. M. F.

von Hayek and the British Museum of Natural History, two syntypes of *suturalis* were made available to the author for comparison.

The most striking difference between the species is the shape of the pronotum, with that of *chinensis* (Fig. 1) slightly more transverse than that of *suturalis* (Fig. 2), and the hind pronotal angles of the former but weakly produced (strongly so in *suturalis*). The lateral pronotal margins of *chinensis* are evenly rounded from front to back and the anterior margin gradually and weakly impressed mesally, while in *suturalis* the lateral margins are slightly produced midway along their length and the anterior margin is more abruptly and deeply sinuate mesally.

Another major difference is the shape of the terminal segment of the maxillary palpus, with that of *chinensis* convexly rounded on its outer aspect and the inner surface deeply excavated to form a cup- or scoop-like structure (in *suturalis* both surfaces are convexly rounded, thus forming a bulbous structure).

The presence of an excavation in the terminal antennal segment of the female makes *chinensis* unique among the Ischaliinae known to the author, since secondary sexual dimorphism has not previously been recorded for the group. Young's (1975) description of the genus must be expanded to include this feature.

I should like to acknowledge D. H. Kavanaugh of the California Academy of Sciences (CASC) and H. B. Leech, formerly of the California Academy of Sciences, for the loan of undetermined Asian Pyrochroidae which produced the specimens of *chinensis*. Also, my thanks are extended to C. M. F. von Hayek of the British Museum of Natural History for the loan of two syntypes of *Ischalia suturalis* Blair, and to S. G. Wellso of Michigan State University for reviewing the manuscript.

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The Genus *Triacetelus* Bates

(Coleoptera: Cerambycidae)

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The purpuricenine genus *Triacetelus* was proposed by Bates (1892) to accommodate a single new species, *sericatus*, from Iguala, Guerrero, Mexico. Zajciw in 1964 described a new genus, *Paramphionthe*, for a species from El Salvador. This species was considered a synonym of *T. sericatus* by Monné and Martins in 1972. In addition to the type species, *sericatus*, we now consider the genus *Triacetelus* to consist of one new species and another previously described one, both from Mexico.

This study was supported by the National Science Foundation (GB-BM574) for a monograph of North American Cerambycidae. We gratefully acknowledge the following institutions and individuals for the loan of specimens from collections in their care: California Academy of Sciences, San Francisco; Canadian National Collection, Ottawa; Cornell University, Ithaca; Essig Museum of Entomology, University of California, Berkeley; University of Kansas, Lawrence; Los Angeles Museum of Natural History; Ohio State University, Columbus; and G. H. Nelson.

GENUS TRIACETELUS BATES

Triacetelus Bates, 1892, Trans. Entomol. Soc. London, 1892:176; Monné and Martins, 1972, Rev. Brasileria Entomol., 16:75.

Paramphionthe Zajciw, 1964, Ann. Acad. Brasileria Cienc., 36:437; Monné and Martins, 1972, Rev. Brasileria Entomol., 16:75 (synonymy). Type: *P. moestula* Zajciw, monobasic).

Form slender, sides subparallel. Head with front subvertical, short, deeply impressed transversely; palpi subequal, short, apical segments cylindrical; mandibles short, barely arcuate, broadly, obliquely truncate at apices; antennal tubercles slightly elevated; antennae slender, about twice length of body in males usually a little longer than body in females, segments slightly expanded at apices, third much longer than first, fourth shorter than or subequal to third, fifth longer than or equal to fourth, eleventh of males very long. Pronotum with acute lateral tubercles at middle; disk convex, middle with a vague linear callus, base with a shallow swelling each side of middle; prosternum not impressed, intercoxal process abruptly declivous, apex narrow, coxal cavities wide open behind; mesosternal process slightly tuberculate at middle, gradually declivous in front; episternum of metathorax broad, slightly tapering posteriorly. Elytra strongly to vaguely bicostate on each side, surface sericeous to metallic; apices strongly to shallowly emarginate to bi-emarginate. Legs slender; hind femora extending

beyond apices of elytra, dentate at apices; hind tarsi slender, first segment longer than two following together, third segment cleft to about middle.

Type species: *Triacetelus sericatus* Bates (monobasic).

This genus is closely related to *Pseudodeltaspis* Linsley but the two may be separated by the strongly five-callused pronotal disk, lack of dense pubescence on the elytra, and by the strongly metallic color of the elytra of *Pseudodeltaspis*.

Three species of *Triacetelus* are presently known, all from Mexico with one species extending to El Salvador.

KEY TO THE SPECIES OF TRIACETELUS

1. Elytra densely clothed with long appressed pubescence which lies transversely on disk, apices bi-emarginate 2
 Elytra densely clothed with very short, appressed pubescence lying longitudinally, apices deeply emarginate, sutures strongly produced, color metallic greenish to violaceous. Length, 19–21 mm. Michoacan *viridipennis*
- 2(1). Pronotum reddish, irregularly punctate, basal lateral callosities not punctate, disk with a prominent, glabrous, median callus. Length, 12 mm.
 Yucatan *emarginata*
 Pronotum black, very densely, confluent punctate throughout, disk with a vague linear callus extending over most of length. Length, 11–18 mm.
 Sinaloa, Mexico to El Salvador *sericatus*

***Triacetelus viridipennis*, new species**

Male.—Form moderate sized, moderately tapering posteriorly; integument black, elytra dull metallic greenish to violaceous; pubescence short, whitish. Head small, front deeply impressed transversely, shallowly, irregularly punctate, densely clothed with pale erect pubescence; median line deep, V-shaped; antennal tubercles shallow, apices obtusely angulate; antennae slender, extending about 4 segments beyond elytra, segments three through ten slightly enlarged at apices, segments finely, densely clothed with very short, reddish-purple, recumbent pubescence, segment three equal to four, fifth slightly longer than fourth, remaining segments very gradually increasing in length to tenth, eleventh twice as long as tenth. Pronotum broader than long, sides rounded with a small acute tubercle on each side; disk convex with a vague, linear, median callus and shallow calluses on each side near base; base broadly impressed; punctures fine, shallow, very dense, contiguous, median callus sparsely punctate; pubescence fine, pale, depressed, dense; prosternum densely pubescent, intercoxal process shallowly carinate at middle, abruptly declivous, narrow behind, coxal cavities wide open behind; meso- and metasternum very finely, densely punctate, densely clothed with long, whitish, appressed pubescence, mesosternal process lying above level of coxae, shallowly tuberculate at middle, gradually declivous in front. Elytra less than $2\frac{1}{2}$ times as long as broad; each elytron vaguely bicostate; punctures very fine, confluent; pubescence dense, very short, depressed; apices strongly obliquely emarginate, lateral angles dentate, sutural angles elongate, obtuse. Scutellum densely white pubescent. Legs with front and middle femora moderately clavate, hind

femora linear, extending to apices of elytra; hind tibiae with a row of dense sub-erect hairs on inner margin. Abdomen minutely, densely punctate and pubescent except for glabrous spot at margin of first segment and glabrous margins of segments 2 to 4; last segment rounded at apex, emarginate at middle. Length, 21 mm.

Female.—Form similar, more parallel-sided. Antennae slightly longer than body, outer segments moderately serrate, third segment longer than fourth, pubescence dark. Abdomen with sternites narrowly glabrous at apices; last sternite broadly truncate at apex. Length, 19 mm.

Holotype male, allotype (California Academy of Sciences) from APATZINGAN, MICHOACAN, MEXICO, 5 August 1940 (Hoogstraal Expd. 40).

The short pubescence and dull metallic greenish to violaceous overall color of the elytra will separate this species from other *Triacetelus*.

TRIACETELUS EMARGINATA (CHEVROLAT), NEW COMBINATION

Cyphosterna emarginata Chevrolat, 1862, Ann. Soc. Entomol. France, (4)2:758.

Gambria emarginata, Lacordaire, 1869, Genera des coléoptères, 9:189; Bates, 1880, Biologia Centrali-Americana, Coleoptera, 5:86.

This species is known only from the unique female type at the British Museum (Natural History). It greatly resembles *sericatus* by the transversely lying pubescence and bi-emarginate apices of the elytra. The pronotum and appendages are reddish with the elytra dark and silvery pubescent. Additionally the disk of the pronotum is irregularly punctate with the basal callosities glabrous. Additional material may indicate that *emarginata* represents a population of *sericatus*. Length, 12 mm.

Type locality.—Yucatan.

TRIACETELUS SERICATUS BATES

Triacetelus sericatus Bates, 1892, Trans. Entomol. Soc. London, 1892:176, pl. 7, fig. 12; Linsley, 1935, Trans. American Entomol. Soc., 61:100; Chemsak, 1967, Jour. Kansas Entomol. Soc., 40:80 (Lectotype designation); Monné and Martins, 1972, Rev. Brasileira Entomol., 16:75.

Paramphionthe moestula Zajciw, 1964, Ann. Acad. Brasileria Cienc., 36:438, fig. 4.

Male.—Integument black, elytra and legs frequently pale brownish. Head with front clothed with fine erect pubescence; antennae about twice as long as body, third segment subequal to fourth, fifth longer than fourth, segments finely pubescent, more densely at apical expansions. Pronotum finely, densely punctate, densely clothed with transverse, appressed pubescence; pro-, meso- and metasternum densely silver-pubescent. Elytra distinctly bicostate on each side, sub-sutural costae not extending to apex; transverse pubescence lying within limits of costae, longitudinal bands extending from humeri to apex subopaque, finely pubescent, often submetallic, lateral margins narrowly brownish; apices bi-emarginate, not produced. Legs with hind tibiae possessing a row of erect bristles along inside margins. Abdomen densely pubescent except for narrow margins of segments 2 to 4; last sternite emarginate at apex. Length, 11–18 mm.

Female.—Form similar. Antennae slightly longer than body, third segment

longer than fourth, fifth equal to fourth. Pronotum finely pubescent, pubescence short, not obscuring surface. Abdomen with last sternite broadly truncate, notched at middle. Length, 12–18 mm.

Type locality.—of *sericatus*, Iguala, Guerrero, Mexico; *moestula*, Cutuco da Union, El Salvador.

Range.—Sinaloa, Mexico to El Salvador.

This species is easily recognizable by the transverse pubescence of the elytra and the finely, densely punctate pronotal disk.

Geographic variation in color appears to be clinal. The northernmost specimens are dark with mostly reddish legs. The elytra, particularly along the outside opaque band are submetallic with greenish to violaceous overtones. In the vicinity of Mazatlan, Sinaloa, the tendency is toward all black coloration including the legs. Further south, in Nayarit, the elytra become brownish and the legs again reddish. This tendency continues southward with the elytra becoming paler brown, and only faintly metallic.

Long series of Mexican specimens have been examined from the following localities: 18 miles S Guamuchil, Sinaloa, 7 August 1964, on *Croton culicanensis* (J. A. Chemsak, J. A. Powell); 29 miles S Culiacan, Sinaloa, 23 June 1963 (J. Doyen); 18 miles N Mazatlan, Sinaloa, 28 July 1972 (J. A. and M. A. Chemsak, A. and M. Michelbacher); 9 miles N Mazatlan, 25–28 July 1972 (Chemsaks and Michelbachers); 5 miles N Mazatlan, 27 July and 1 August 1972, on *Buddleia wrightii* (Chemsaks and Michelbachers), 5–7 July 1964 (J. E. Martin) 14 km S Mazatlan, 18 July 1965 (R. Snelling); 4 miles S Villa Union, Sinaloa, 23 June 1963 (J. Doyen); Arroyo Santiago, nr. Jesus Maria, Nayarit, 5 July 1955 (B. Malkin); 35 miles W Tequila, Jalisco, 22 July 1965 (P. H. Freytag, L. P. Gibson); 6 miles S Rio Mexcala, Guerrero, 6 August 1965 (G. H. Nelson); Mexcala, Guerrero, 29 June 1951 (P. D. Hurd, H. E. Evans); Bejucos, Temescaltepec, Mexico, 3 July 1933 (Hinton and Usinger); 20 miles S Matias Romero, Oaxaca, 2 July 1964 (A. Raske); 21 miles S Matias Romero, 25 June 1961, on *Acacia* flowers; 14 miles NW Tehuantepec, Oaxaca, 26 June 1961; 3 miles W Tehuantepec, 9 July 1965 (G. H. Nelson).

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New Species of North American *Anomala*

(Scarabaeidae: Anomalinae)

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During revisionary study of the species of *Anomala* of America north of Mexico the following seven species were discovered to be new. All of the new species are apparently from relatively small geographic areas, and at least two or three are from very limited relictual habitats.

Anomala diabla, new species

Holotype male.—Medium brown, head and clypeus red-brown, pronotum with large central red-brown macula extending to base, enclosing paler area medio-basally, elytra with narrow complete outer margin and sutural interval red-brown, this extending forward around scutellum and along base; scutellum almost median in hue between ground color and maculation. Thoracic sternites finely, not densely pilose. Protibiae tridentate; larger protarsal claw simple; larger mesotarsal claw finely but rather deeply cleft well back from apex. Antennal club slightly longer than stem. Clypeus trapezoidal, more than twice as wide as long; sides moderately divergent, broadly and strongly reflexed marginally; suture slightly depressed; disc of clypeus together with triangular area of front notably flattened, coarsely, irregularly punctate (more reticulate under higher magnification). Vertex with dense, fine, laterally elongate punctures. Pronotum evenly arcuate laterally, broadest near middle; anterior angles distinct, almost square; posterior angles broadly rounded; punctures moderately fine, not dense, but becoming more so laterally; basal bead fine, complete. Elytra slightly broader behind middle; striae slightly grooved, regularly, finely punctate, the punctures darker, particularly toward suture; subsutural interval markedly widest, multipunctate basally; other intervals subequal, 4th and 6th with scattered punctures; striae becoming irregular laterally. Pygidium punctate, punctures similar to those of pronotum but more irregular. Length, 9 mm.

Holotype male, TEXAS, DEVIL'S RIVER, near DEL RIO, 25 May 1932 (CAS); one male paratype, Texas, Eagle Pass, 2 June 1923 (Howden).

Holotype placed in the collection of the California Academy of Sciences and the paratype in the collection of Henry Howden.

The paratype is remarkably similar to the holotype, except that the larger mesotarsal claw is simple, and the elytral striae are more roughly punctate.

Named for the river where the type specimen was collected. The species superficially resembles *cavifrons*, but is without the elongate clypeus and carinate clypeal suture. It also has distinctly tridentate protibiae. These characters, with the simple protarsal claw, distinguish it from the

somewhat similar *delicata*, and some specimens of *undulata*, with which it might be confused.

***Anomala eximia*, new species**

Holotype male.—Head, pronotum and scutellum dark red-brown-black, elytra straw-colored; margins, punctures, and two vague irregular bands at middle before apex brown-black. Venter with sparse, moderately long pale pilosity. Mesocoxal separation moderate, about width of tarsal segment. Protibia without external tooth, terminal tooth moderately long, terminal articulated spine small, inconspicuous. Larger protarsal claw finely cleft near middle, upper ramus small, spine-like, closely appressed; larger mesotarsal claw finely cleft near apex. Metatibia as long as femora, moderately surate. Clypeus subrectangular, about twice as wide as long; sides slightly divergent, broadly, strongly reflexed; anterior face thick, vertical, rounded under to small exposed labrum; suture a little depressed; disc of clypeus together with triangular flattened area of head shallowly punctorugulose. Antennal club somewhat longer than stem. Pronotum slightly arcuate behind, about same width at base as at middle, then more strongly arcuate to square anterior angles; posterior angles broadly rounded; discal punctures rather coarse, irregular, contiguous to separated by 1–2 diameters, not becoming larger nor more dense at sides; basal bead very fine, entire. Elytra widest about middle; strial series very irregular, formed by individual punctures intermixed with short and long foveate groups of punctures; intervals scarcely distinct, but 2nd and 4th broader, 2nd very irregularly multipunctate, 4th with uniseriate row of scattered punctures. Pygidium finely rugose with sparse, moderately long pilosity. Length, 7 mm.

Holotype male, 8 male paratypes, FLORIDA, HIGHLANDS CO., ARCHBOLD BIOLOGICAL STATION, at Malaise Trap, 12–19 June 1969, R and J Matthews, Collrs. (UGA).

The Holotype is deposited in the collection of the U. S. Museum of Natural History, with paratypes in the collections of the University of Georgia and the author.

The species varies in size from 6.5 to 7.5 mm. The clypeus commonly has the sides parallel or even slightly convergent basally. The elytral sculpture and coloration is quite variable and the two irregular dark bands are sometimes lacking.

This is the second small species from Florida that has the protibiae lacking an external tooth, the other being *exigua* (Schwarz), however, while the similarity is interesting this species is not close to *exigua*, but belongs in the *binotata* series.

***Anomala hardyorum*, new species**

Holotype male.—Pale straw-colored; clypeal margin, anterior and posterior pronotal margins, sides of scutellum and elytral suture very narrowly reddish-brown; pronotum and elytra immaculate but variably pale due to irregular sclerotization. Thoracic sterna moderately pilose. Midcoxae narrowly separated. Anterior tibiae bidentate, lateral tooth not prominent, formed by excavation to terminal tooth; terminal articulated spine large and prominent; larger protarsal claw narrow,

barely perceptibly thickened basally, cleft deep, at about middle, with upper ramus fine, spine-like, much shorter than lower ramus. Metatibia much shorter than femur, barely longer than first 3 tarsal segments. Antennal club thin, slightly asymmetrical, notably longer than stem. Clypeus trapezoidal, more than twice as wide as long; strongly reflexed at margins; anterior face steeply oblique, then rounded beneath to narrow edge of exposed labrum; clypeofrontal suture flat at sides, depressed medially; front of head broad, subrectangular; both clypeus and front finely rugosely punctate. Pronotum widest at base, very broadly subangulate before middle, sides straight posteriorly, barely arcuate anteriorly to nearly square anterior angles; posterior angles obtuse, narrowly rounded; discal puncturation very fine with punctures separated by up to 3-4 diameters; basal bead fine, entire, depressed below discal plane. Elytra broadest near middle; 10 primary striae very weakly or not at all grooved, indicated by small punctures, each in a larger depression, these contiguous in a row or separated and irregular; subsutural interval slightly broader, multipunctate anteriorly, thinning posteriorly and punctures scarcely reaching apex; 4th interval substriately punctate much of length; 3rd, 5th and 7th intervals narrower but irregular, very slightly costate; micropunctures generally distributed over elytra. Pygidium with large, shallow, irregular punctiform depressions becoming finely rugose in part. Length, 9 mm.

Female.—Similar to holotype, but with pygidium much more finely and sparsely punctate; protibiae strongly bidentate with lateral tooth prominent; antennal club heavy, subequal to stem; larger protarsal claw evenly terminally cleft, upper ramus as large as and longer than lower ramus.

Holotype male, CALIFORNIA, IMPERIAL CO., 3 mi. NW GLAMIS, 12 April 1969, A. Hardy, (Hardy Collection); Allotype, same data, 23 April 1970, Hardy & Pritchard, (Hardy Collection); 93 males, 8 females, same data, 3 April to 5 May, 91 males, 10 females, same except various stations nearer Glamis, various dates between 26 March and 4 May.

Holotype, allotype and paratypes placed at California Academy of Sciences; paratypes in the collections of California Department of Agriculture, University of Arizona, Dave Carlson, J. M. Cicero, Alan Hardy, H. F. Howden, G. F. Nelson, Ron Mc Peak, and the author.

Male paratypes varied from 7 to 10 mm, the females from 7 to 9 mm; both were sometimes a little darker, sometimes with faint pronotal clouding of a darker hue. The size and length of the upper ramus of the larger protarsal claw was quite variable in both sexes.

Named in honor of Alan and Wanda Hardy who have made many trips to the Glamis dunes, studying the remarkable relict fauna and flora of the area.

***Anomala imperialae*, new species**

Holotype male.—10 mm. Light brown; with head, clypeus, anterior and posterior margins of pronotum, broad sutural and lateral margins of elytra and some elytral punctures dark brown. Beneath strongly pilose with mixture of short and moderately long hairs. Mesocoxae narrowly separated. Protibiae tridentate; larger pro- and mesotarsal claws simple. Antennal club distinctly longer than stem. Ligula

with more than normal number of erect setae but not enough to be confused with penicillate ligula of much smaller *Leptohoplia*. Clypeus trapezoidal, more than twice as wide as long; sides moderately divergent; margins narrowly, abruptly reflexed; discally with fine transverse rugae and small scattered punctures; front more strongly, irregularly rugosely punctate. Pronotum almost evenly arcuate at sides; anterior angles almost square, a little rounded; posterior angles broadly rounded; discal punctures very fine, shallow, becoming much larger and very irregular laterally; basal bead complete, very fine laterally, heavier medially. Elytra broadest about middle; striae not at all or only slightly grooved, formed by rows of pale to dark irregularly spaced fine punctures; subsutural interval broad, multipunctate anteriorly; other intervals of variable widths but all relatively narrow. Pygidium strongly, irregularly punctate.

Female.—11.5 mm, similar except antennal club heavier, about as long as stem; larger protarsal claws mixed, the left simple, the right broadly cleft; clypeus and front more roughly, irregularly punctate; pronotum with two small close-set antero-medial dark brown maculae.

Holotype and 4 male paratypes, CALIFORNIA, IMPERIAL Co., WINTERHAVEN, 3–4 April 1961, Maxwell, Collr. (CDA); Allotype and 2 male paratypes, Arizona, Yuma, 27 April 1962, 3 April 1961, 3 May 1962, Yanez, Mellor and Stedman, Collrs. (UAZ); 8 male paratypes, California, Imperial Co., Bard and Laguna Dam, 5 April to 3 May, Harrison, Akins, Miller and Cicero, Collrs. (CDA, Nelson and Cicero Colls.); 9 male paratypes, Arizona, Yuma Co., Laguna Dam and 5 mi. W Wellton, 10 Aug and 8 Oct, Nutting & Werner and Fisher, Collrs. (UAZ and Hardy Colls.); 1 male paratype, Arizona, Huachuca Mtns (USMNH); 1 female paratype, Arizona, Santa Catalina Mtns, Sabino Canyon, 17 May, Woods, Collr. (UAZ).

Holotype deposited at California Academy of Sciences, and allotype in University of Arizona Collection, on indefinite loan to California Academy of Sciences; paratypes in the collections of the above and California Department of Agriculture, U. S. Museum of Natural History, J. M. Cicero, Alan Hardy, H. F. Howden, G. H. Nelson and the author.

Paratypes vary from 8 to 11 mm. About half the males have transverse wrinkles on the clypeus, the others are strongly, irregularly punctate. The amount of dark maculation is variable, from almost none to very broadly margined and with the pair of small pronotal maculae, while the female has the pronotum immaculate. The female also has the larger claw of the protarsus broadly cleft, but all males have the claw simple.

***Anomala kanei*, new species**

Holotype male.—9 mm. Pale straw-colored, head and clypeus brown-black, pronotum with pair of small triangular anteromedial spots dark-brown, scutellum and elytra with extreme marginal edges red-brown and some clouding of brown inward from lateral margins. Beneath with short, not dense pilosity. Mesocoxal separation narrow. Protibiae strongly bidentate, terminal tooth long, slender, external tooth long, acute; larger protarsal claw strongly but finely cleft about middle; larger mesotarsal claw finely, deeply cleft well back from apex. Metatibia shorter

than femora, about as long as first 4 segments of tarsi but distinctly more than twice as long as width at apex. Antennal club much longer than stem, lamellae thin, somewhat twisted. Clypeus somewhat elongate, about twice as wide as long, sides subparallel toward base, very strongly and broadly reflexed to margins; anterior face strongly rounded under to porrect labrum; clypeofrontal suture deeply impressed in part; clypeus and front very irregularly rugulose and somewhat punctate, varying from large punctiform craters to small distinct punctures. Pronotum evenly arcuately rounded laterally, widest about middle, both anterior and posterior angles broadly rounded; moderately densely punctate, punctures shallow, fairly large; with faint indication of median line; basal bead distinct, entire. Elytra a little wider behind middle; striae broadly but not deeply impressed, with spaced, poorly defined strial punctures; entire discal surface with numerous micropunctures; subsutural interval distinctly widest but may be apparent only basally and apically as single row of large punctures forms substrate line at middle. Scutellum with slight posteromedian depression. Pygidium densely punctate, but punctures shallow, moderately large, irregular in shape and definition.

Female.—9 mm; very similar, differing primarily in sexual characters: antennal club about length of stem; protibial dentition still more acute and longer; larger protarsal claw almost evenly cleft with upper ramus a little smaller and shorter; larger mesotarsal claw with upper ramus a little larger and longer.

Holotype male, allotype, and 94 male paratypes, ARIZONA, COCONINO Co., 2 mi. S. MOENKOPI, 3 July 1972, Andrews and Kane, Collrs. (CDA); other paratypes from Arizona, Coconino Co.: 3 males, 2 mi. S. Moenkopi, 15 July, J. & L. Shepard, Collrs. (Hardy); 1 male, Kayenta, 23 July, Maehler, Collr. (Potts); 3 males, Tuba City, 1 July, 1 Aug, Allen, Cazier, Collrs. (CAS, CNC, and USMNH Colls.); and from Arizona, Navajo Co.; 7 males, 1 female, Aug, Duncan, Collr. (UAZ); 1 male, Winslow, 5 July, Johnston, Collr. (CNC); and 2 males, Utah, Kanab, 20 July, Knowlton and Harmston, Collrs. (USMNH).

Holotype and allotype, with paratypes in the collection of the California Academy of Sciences; paratypes also in the collections of the California Department of Agriculture, Canadian National Collection, University of Arizona, U. S. Museum of Natural History, Alan Hardy, and the author.

The male paratypes vary from 7 to 9 mm, with head and clypeal color varying from only a little darker than pale straw ground color through red-brown to brown-black, the pronotum sometimes becoming immaculate and elytral sculpture sometimes very shallow and faint. The female paratype is heavier, with darker ground color, but dark maculations paler.

This attractive small species, appearing closest to *antennata*, is named in memory of Fred Kane.

***Anomala sabinae*, new species**

Holotype male.—15 mm. Light straw-colored, with clypeus, head, and antero-medial pronotal macula red-brown, posterior margin of pronotum, lateral margins of scutellum and narrow sutural stripe of elytra brown-black. Beneath with moder-

ately short pilosity on thorax, abdomen almost glabrous. Mesocoxal separation narrow, but almost as wide as a tarsal segment. Protibiae strongly bidentate; larger protarsal claw strongly cleft with smaller ramus fine, slightly longer than larger ramus; larger mesotarsal claw with cleft nearly similar; metatibiae strongly surate and metatarsi exceptionally heavy as in *delicata*, about twice as wide as other tarsi. Antennal club slender, about as long as stem. Clypeus trapezoidal, more than twice as wide as long; sides strongly divergent; very narrowly reflexed at margins; anterior face distinctly oblique to exposed narrow portion of labrum; suture flat; front of head broad, rectangular; clypeus and front finely rugosely punctate. Pronotum widest at base with sides evenly arcuately narrowing to square anterior angles; posterior angles a little obtuse, slightly rounded, disc very finely, not densely punctured, punctures separated by 2-4 diameters, not becoming more coarsely nor more densely punctate at sides; basal bead obsolescent medially. Elytra broadest about posterior third; striae series with distinct geminate pairs, the 3rd, 5th and 7th intervals very narrow, a little costate, and a similar 9th interval barely discernible; subsutural and other alternate intervals broad, multipunctate; striae punctures somewhat smaller than those of intervals, but all formed by a micropuncture in a pit. Pygidium very finely and densely, but shallowly strigulose.

Female.—14.5 mm; similar, however central pronotal macula complete to base, enclosing pale mediobasal area; pygidium not strigulose, but with very fine, shallow, laterally much elongated punctures, about 2-4 diameters apart; elytra with small dark spot over humeral umbone; other variation as normal for sex: tarsal claws more evenly cleft, protibiae more strongly dentate, antennal club heavier, but about as long as in male.

Holotype and allotype, ARIZONA, SANTA CATALINA MTNS., SABINO CANYON, in oak-mesquite-sycamore association along permanent stream, 2500', 26 July 1948, Werner & Nutting, Collrs. (UAZ). All paratypes, 28 males, 18 females, also from Sabino Canyon, various dates between 21 June and 4 September, Werner & Nutting, Butler, Johnson, Potts and Potts, Cicero, O'Brien, Hovore, Collrs. (UAZ, Potts, Cicero, Woodruff, Howden, and Carlson Colls.)

Holotype and allotype in the University of Arizona collection, on indefinite loan to the California Academy of Sciences, and paratypes in the collections of the Academy, as well as in the U. S. Museum of Natural History, University of Arizona, Carlson, Cicero, Hardy, Howden, Woodruff, and the author.

The paratypes vary between 13 and 17 mm. and sometimes become medium brown, the males usually with the pronotal macula antero-medial, rarely reaching to the base, while in the females the macula is almost always complete to base. Also, the males rarely show the dark macula over the humeral umbone, while it is usual in the female.

The species is very similar to, but consistently larger than *delicata*, and it has relatives of equal size in southern Mexico.

***Anomala suavis*, new species**

Holotype male.—8 mm. Pale straw-colored, with dark brown-black head and clypeus, pronotum with large central dark brown macula complete to basal margin,

scutellum and narrow entire margin of elytra dark brown. Moderately short pilose beneath. Mesocoxal separation narrow. Protibiae strongly bidentate, terminal tooth slenderly elongate, external tooth acute, longer than normal in genus; larger protarsal claws distinctly but finely cleft about middle; larger mesotarsal claws finely, deeply cleft well back from apex; metatibia notably short, shorter than femur, about length of first 4 segments of tarsus, only barely surate, but definitely more than twice as long as width at apex. Antennal club much longer than stem. Clypeus elongate, less than twice as wide as long, sides strongly convergent basally, strongly and broadly reflexed to margins; anterior face thick, strongly rounded under to small, slightly projecting anterior aspect of labrum; clypeofrontal suture slightly depressed; irregularly, finely rugosely punctate over clypeus and a small triangular area of front of head; head very finely punctate over vertex. Pronotum very evenly arcuately rounded laterally, widest behind middle; anterior angles obtuse but distinct; posterior angles very broadly rounded; with fine, shallow median line; discal punctures fine, not dense centrally but becoming more so laterally; basal bead not well-defined medially. Scutellum with distinct posteromedial depression. Elytra widest a little behind middle; striae irregularly, somewhat broadly impressed, with punctures often indistinct, fine to large; subsutural interval broadest, with scattered very large rough punctures becoming almost striate series at middle but not continuing to apex. Pygidium with scattered, shallow, irregular punctures.

Holotype and one male paratype, TEXAS, WINKLER CO., 4 mi. NE KERMIT, 5 June 1971, O'Brien and Marshall. Holotype on deposit at the California Academy of Sciences and paratype in the collection of the author.

Another of the species that is relatively close to *cavifrons*, but also another with well cleft protarsal claws, and the two known specimens are extremely clearly and neatly marked. In this respect they are quite unlike the usual *cavifrons* specimens that show some melanistic maculation.

A New Species of *Evodinus* From Wyoming

(Coleoptera: Cerambycidae)

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Three specimens of a distinct Lepturine Cerambycid from Beartooth Plateau, Park County, Wyoming, were received for identification from the University of Colorado Museum by Dr. U. N. Lanham. A fourth specimen, included in the following description, was made available by Dr. John A. Chemsak, University of California, Berkeley. It was collected in Wyoming in 1897, is faded, and in poor condition, but is unmistakably conspecific with the original three.

Evodinus lanhami, new species

Female.—Form moderate sized, robust; color piceous to black; antennae except scape, tibiae and tarsi reddish brown, elytra yellow with black markings. Head trapezoidal, widest across eyes, only slightly narrower than widest portion of pronotum; frons and tempora shining; pubescence moderately depressed, not obscuring surface; punctation densely, coarsely, contiguously to rugosely punctate. Antennae 11 segmented, robust, extending to basal third of elytra; scape black, remainder of segments reddish brown with apex of fourth through eleventh subopaque, distinctly minutely pubescent without apical cilia; third segment subequal to scape, longer than fourth. Remaining segments subequal.

Pronotum about as wide as long, robust, shining, strongly obtusely tuberculate laterally; coarsely, densely, contiguously punctate; apex narrower than base; a poorly defined narrow median line extends from apical sulcus to basal margin; pubescence moderate, suberect to erect, not obscuring surface. Prosternum moderately densely pubescent and rugulose; meso- and metasternum moderately pubescent, surface not obscured. Elytra less than twice as long as broad, sides to apical third slightly tapering to subparallel, then gradually rounded to suture; apices slightly dehiscent; densely, coarsely, confluent punctate with punctation becoming finer apically; pubescence golden, short, uniform, and semirecumbent; color yellow with black markings as follows: Basal margins triangularly expanded posteriorly to envelope scutellum, then extending to apex as a sutural vitta, and continuing over humeri obliquely posteriad as a maculation connecting or not with the suture; a small medial lateral spot; a larger post median black macula which may be expanded to reach suture and apices. Legs slender, femora black; tibiae and tarsi lighter; pubescence fine, uniform, not obscuring surface. Abdomen moderately pubescent, shallowly densely punctate; 5th sternite broadly rounded; 5th tergite subtruncate, narrowly notched. Length 13–14 mm; width 5.5 mm.

A KEY TO THE NORTH AMERICAN SPECIES OF *EVODINUS*

1. Pronotum dull, distinctly longer than wide; punctation fine; pubescence moderately dense. Elytra with humeri yellow, without a distinct black sutural vitta *monticola*

Pronotum shining, distinctly coarsely punctate, about as wide as long; pubescence moderate. Elytra with basal margin black extending over humeri. -----
lanhami

E. lanhami can be easily recognized from its other U. S. counterpart *E. monticola* by its more robust form, subparallel sided elytra, transverse pronotum, and elytral maculation. It is apparently taken at high altitudes.

Holotype female, BEARTOOTH PLATEAU, PARK COUNTY, WYOMING, 15-17 June, 1961.

Paratypes, three females—two with above data; one, Pammel, Rapid Creek, Wyoming, 7-97, R. Hopping Coll. The type is deposited in the Colorado University Museum. Paratypes are deposited in the California Insect Survey, Berkeley; the California Academy of Sciences, San Francisco; and the collection of the author.

ACKNOWLEDGMENTS

The author wishes to thank Dr. John A. Chemsak, University of California, Berkeley, for examining the material and comparing it with old world members of the genus, and Dr. U. N. Lanham, for whom the species is named, for making the original specimens available for study.

RECENT LITERATURE

A BIBLIOGRAPHY AND A KEYWORD-IN-CONTEXT INDEX OF THE CERATOPOGONIDAE (DIPTERA) FROM 1758 TO 1973. W. R. Atchley, W. W. Wirth and C. T. Gaskins. Texas Tech University Press, Lubbock, 1975. 300 pp. \$4.00 (paper).

The title accurately describes the contents of this computer produced literature guide, which will unquestionably be useful to researchers interested in this family of flies. The bibliography (number of entries not mentioned) occupies 161 pages. Single line keyword indexing comprises the remaining 130 pages. A short introduction provides instructions for use. An exact description of the data base used to construct this bibliographic aid is not provided.—*Editor*.

**Predatory Behavior of the Spider Wasp,
*Chalybion californicum***

(Hymenoptera: Sphecidae)

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Chalybion californicum (Saussure) (= *caeruleum* of authors) is a common steel-blue mud-daubing spider wasp found throughout most of North America from southern Canada into Mexico (Bohart and Menke, 1963). Its nesting biology has been studied by Rau (1928a, 1928b), but only a few isolated observations of its predatory behavior have been reported. The Peckhams (1898) observed a species of *Chalybion* preying on *Araneus cornutus* Clerck (= *Epiera strix*). The wasps crawled into cracks and corners of cottage walls and dislodged the spiders. They captured spiders with their mandibles and forelegs and stung them at that time or after taking flight. Rau (1928a) observed a *C. californicum* attempting to capture a *Lycosa* spider by landing on its back. Howard (1922) reported that Schwarz (presumably Herbert F. Schwarz) observed *C. californicum* entangling itself in webs and causing spiders to run out of their retreats. The wasps would then free themselves and pursue the spiders. Frost (1944) reported this species engaged in the same behavior.

Observations reported here were made on eight days from June 27 to July 17, 1974, on the campus of the University of California, Berkeley, and confirm the pattern in the accounts of Howard (1922) and Frost (1944). *C. californicum* females employ an efficient form of aggressive mimicry in capturing their prey. This activity took place on one *Garrya elliptica* Dougl. bush harboring a large population of immature *Zygiella x-notata* (Clerck), an araneid spider. *Z. x-notata* constructed orb webs that usually had one of the dorsal pie-slice shaped sectors missing. From the center of each orb web a strong signal line ran to a tubular retreat, usually above the orb. The leaves of *G. elliptica* are oblong with the lateral edges curled under. The sheltered undersides of the leaves provided suitable retreats for *Z. x-notata*, and openings in the foliage provided many locations for their webs. During the day, the spiders remained in their retreats and used their front legs to monitor the signal line for vibrations transmitted from the orb. *Chaly-*



FIG. 1. *Chalybion californicum* female pulling and vibrating the web of an immature *Zygiella x-notata*.

bion females were about four or five times as large as *Zygiella*. In approximately eleven hours of observations at least three individual wasps vibrated webs more than a hundred times and captured more than twenty spiders.

In a typical sequence a *Chalybion* female flew into openings in the

foliage where she then slowly flew into the exposed face of an orb web and alighted. After remaining motionless for a few seconds, she began pulling on the web with her legs (Fig. 1), mimicking an entangled insect. After several seconds of pulling and vibrating a web, she took flight and repeated the performance on the next orb she encountered. This continued until a spider, responding to the vibrations of its web, ran down the opposite side of the orb from the wasp. Just as a spider was about to reach her, the wasp lunged forward, seized the spider with her mandibles and forelegs, curled her abdomen up underneath her body and stung the spider for several seconds. The exact placement of the sting could not be observed. One spider avoided capture by dropping off the web just as a wasp lunged for it, and the wasp did not pursue it. None of the wasps became entangled in a web.

After a wasp stung a spider, she presumably transferred it to the other side of the web, but this could not be observed. She then carried it across the web to a leaf or stem and then manipulated and rolled the spider with her forelegs and mandibles, in the manner described by the Peckhams (1898). Occasionally a spider was stung again after manipulation. One wasp was disturbed while manipulating a spider. She flew to another leaf and started manipulating the spider again but then dropped it, apparently by accident. Rather than trying to find the spider, she groomed herself for a few seconds and then flew to two more orbs before flying away.

Wasps frequently interrupted their hunting and landed on leaves to groom themselves, and sometimes they walked over the leaves and stems. Twice wasps walked to the lower edge of an orb and used their forelegs to vibrate the web. One spider responded to these vibrations and was captured by the wasp. Several times wasps walked on leaves that had spider retreats underneath. They often crawled around the side of such a leaf, as if examining the retreat, but none attempted capture of spiders in their retreats.

About half the spiders did not respond to the vibrations of their webs. A smaller proportion left their retreats but then returned before approaching the wasp. One spider with a relatively exposed web near the top of the bush repeated this sequence three times in response to one wasp. Spiders were never pursued. They were captured only if they ran to the wasp. The wasps were unable to perceive whether a web contained a spider because they often visited vacant webs.

When attempting to alight on the webs the wasps flew slowly with their legs outstretched and hanging below their bodies. In this position the tarsi were oriented approximately perpendicular to the direction of

flight and anterior to the body and wings, enabling contact of the web by the tarsi, rather than the body or wings. After alighting, wasps used their tarsal claws to hang onto and pull the webs (Fig. 1). Other contact points may be the arolia and the ventral surface of the tarsal segments.

Muma and Jeffers (1945) found that Theridiidae and not Araneidae were the most common prey of *C. californicum*. They concluded that the species of spider preyed upon depends on where the wasp hunts. This is usually on or near the ground and around human habitation, the haunts of most theridiids, but in several cases they found that the wasps only collected foliage inhabiting spiders. This suggested that once a wasp captured a spider, it returned to the same area on subsequent trips. In the observations reported here two female wasps were marked with a nontoxic paint at the *Garrya* bush, but only one of them was seen again, when it returned the following day and captured a spider.

This bimodal distribution of prey type suggests flexibility in predatory behavior of *C. californicum* because there are important biological differences between many theridiids and araneids (Bristowe, 1971). Most theridiid webs are 3-dimensional mazes; most araneid webs are 2-dimensional orbs. When araneids subdue their prey, they usually run to the entangled insect and immediately bite it or wrap it first in silk. Many theridiids often keep their distance and cast silk threads over their prey. Only after the insect is covered with silk and immobilized, do they approach to bite it. Recalling the observations of the Peckhams (1898) and Rau (1928a), it may be that *C. californicum* becomes conditioned to certain prey species and this is reflected in variations in its predatory behavior.

ACKNOWLEDGMENTS

I wish to thank Mr. Charles Griswold for identifying the spiders and Dr. John L. Strother of the Botany Herbarium, University of California, Berkeley, for identifying the *Garrya* bush involved in the study. I also wish to thank Dr. Howell V. Daly and Dr. Jerry A. Powell of the Department of Entomological Sciences, University of California, Berkeley, for their helpful comments and criticisms.

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BOOK NOTICE

RHOPALOCERA DIRECTORY. John R. Beattie. 370 p. (approx.) including introduction and detailed instructions for use. 128,800 entries plus two supplements of 5,000 entries and 36,700 entries. Offset reproduction, soft cover. \$40.00 to libraries, \$30.00 to individuals on 10-day free trial examination. Available June, 1976, from JB Indexes, 2377 Virginia Street, Berkeley, California 94709.

This first volume in an ambitious undertaking to be called the *Insecta Directory* is a computerized index to all generic and specific butterfly names which have appeared in the *Zoological Record* Systematic Indices between 1864 and 1971. It also includes names from the analogous German publication, *Berichte über die wissenschaftlichen Leistungen im Gebiete der Entomologie* for the period 1834-1863. The index supplies the year and page number for each reference to each name in a convenient, easily scanned format, enabling the user to quickly locate the pertinent references in the *Record* or in *Berichte*, without searching each annual volume.

This should be an extremely valuable literature aid for taxonomic work. Since the *Zoological Record* and *Berichte* concentrate on new-name and status-change references, with only selective inclusion of other references, it will not be possible to construct complete synonymies using the directory. Nevertheless the *Rhopalocera Directory* will provide an advanced point of departure for many projects, particularly those oriented towards the world literature, and will also supplement the *Nomenclator Zoologicus* in placing generic names to family. Additional volumes are planned to eventually include all orders of insects.—EDITOR.

***Fannia thelaziae*, A New Species of Eye-Frequenting Fly
of the *benjamini* group from California and
Description of *F. conspicua* Female¹**

(Diptera: Muscidae)

WILLIAM J. TURNER
Washington State University

Fannia benjamini Malloch is a familiar eye-frequenting fly common to dry chaparral and oak woodland areas throughout California. Its annoying habit of frequenting the face and especially the eyes of animals in search of moisture and other substances has made *F. benjamini* the prime suspect as the intermediate host of the mammalian eyeworm, *Thelazia californiensis* Price (Winkler and Wagner, 1961). The eyeworm infests a variety of mammal hosts including deer, rabbits, dogs and man. Although developing stages of the worm were reported in *F. benjamini* (Burnett, *et al.*, 1957), recent transmission experiments provided no evidence of its association with this fly as an intermediate host (Weinmann, *et al.*, 1974).

In recent studies of the biology and oviposition behavior of *Fannia* species laboratory colonies were established at the University of California (Berkeley) (Anderson, J. R., C. J. Weinmann and P. Rubtsoff, unpubl. data). The original colony stock consisted of wild-caught flies captured at three sites in central and northern California during 1968. These laboratory colonies of flies were initially thought to consist only of *F. benjamini*, but minor differences in the eggs eventually produced suggested that a mixed colony with as many as three species was involved (*op. cit.*). Subsequent isolation and rearing of each type of egg yielded pure colonies of each species, *F. benjamini*, *F. conspicua* Malloch, and the new species described here. Only the latter proved to be suitable for the development of eyeworms to the infective stage (Weinmann, *et al.*, 1974).

Chillcott (1960) in his monographic revision of the Fanniinae recognized nine Nearctic species belonging to the *Fannia benjamini* group which could be divided further into three subgroups. *Fannia clavata* Chillcott and *micheneri* Chillcott were placed in the *vittata* subgroup, *setifera* Chillcott constituted the *setifera* subgroup, and six species were included in the *benjamini* subgroup: namely *F. arizonensis* Chillcott, *F. benjamini*, *F. conspicua*, *F. neotomaria* Chillcott, *F. operta* Chillcott, and *F. tescorum* Chillcott. Species in the latter subgroup are distin-

¹ Scientific paper 4561, College of Agriculture Research Center. Research was conducted under Project 9043.

guished from other *Fannia* by their yellow basal antennal segments and palpi, hind tibiae bearing one anterodorsal and two anteroventral bristles, and trimaculate abdomen. Additional characters uniting this subgroup include similarities in male genitalia and female spermathecae.

To facilitate comparisons between species in the *benjamini* subgroup treated here, the format for descriptions and illustrations follows that of Chillcott (1960) and the key to species of the subgroup is based primarily on characters used by him. The key to males is modified to include *F. tescorum* which was inadvertently omitted from the original key (see Chillcott, p. 43, couplet 15). Standard abbreviations were used for bristles and leg segments and include: anterodorsal (ad); anteroventral (av); posterodorsal (pd); posteroventral (pv); dorsal (d); acrosticals (acr); dorsocentrals (dc); coxa (C); femur (F); and tibia (T).

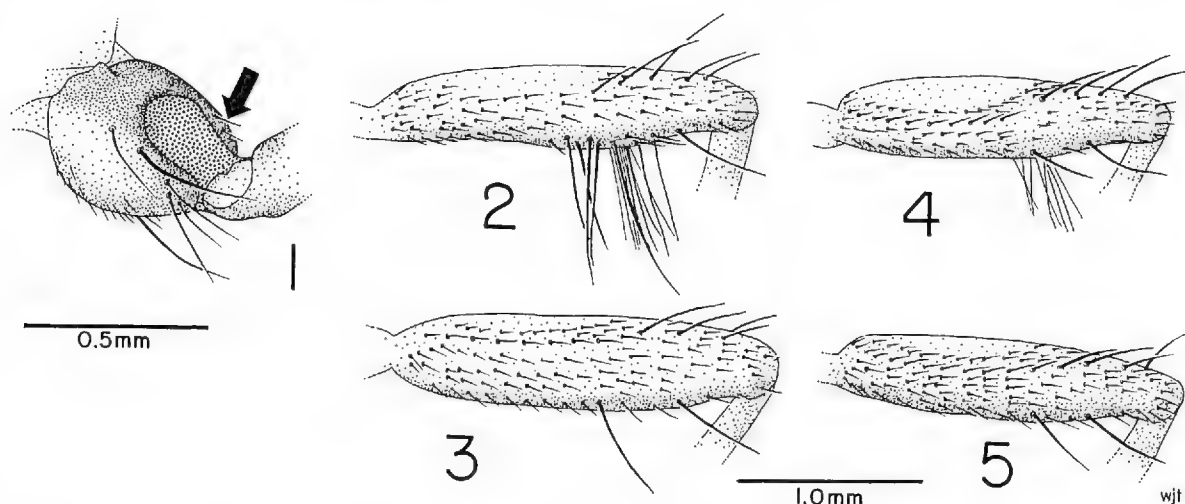
***Fannia thelaziae* new species**
(Figs. 4–8)

MALE: Head.—Front with nine, strong bristles. Parafrontals narrow (0.04 increasing to 0.80 mm), gray pollinose. Parafacials narrow, shining gray, without setulae. Occipital bristles short, regular; postoccipital setulae on lower third, sparse. Second antennal segment yellow; third segment brownish black or sometimes very narrowly yellowish at base, arista brown and weakly pubescent. Palpus yellow, subspatulate. Theca normal.

Thorax.—Evenly brown pollinose, vittae only faintly indicated behind when viewed from rear. Scutellum concolorous with scutum, laterobasal spots distinct. Acrosticals (Acr) evenly triserial. Prealars one or (usually) two strong, short setulae; stigmal setulae absent. Mesopleural bristling distinctly stronger anterodorsally. Squamae pale, lower with margin brownish and slightly larger and projecting more than upper; halter yellow.

Abdomen.—1.5 by 1.8 mm. Basal three segments distinctly translucent yellow laterally, grayish white pollen of darker portions reduced in these areas. Median vitta linear, dark brown, confluent with broad concolorous lateral brown marks on posterior area of basal segments, dark color encompassing entire fifth and following segments, color often obscured by grayish pollen.

Legs.—Legs brown, femora darkly infuscated basally; tibiae and tarsi black. F_1 pvs weak on basal half. T_1 ads weak, median bristle absent. F_2 avs on basal half 6 to 8, equally spaced, strong, none reduced to setulae, 3 median bristles stronger, followed by shorter and close-set comb of 14 to 16 bristles to apex; pvs with single strong bristle basally followed by shorter, partially double row of mixed bristles on basal half, then 6 to 8 stronger ones to three quarters, then decreasing in size to a close-set preapical comb of 6–10 short bristles, the comb tending slightly postero-dorsally. T_2 with biserial ventral mat, half tibial diameter on apical two-thirds, slightly stronger and longer on apical half. C_3 lacking pv setulae. F_3 (Fig. 4) normal in shape, avs prostrate becoming setulose on basal half and two (rarely three) strong, separated preapical bristles; pvs basally fine then with 8–10 long, slender bristles loosely clustered at two-thirds extending basad along the posterior surface as slender erect setulae. T_3 with two avs, one ad and no pv bristles.



FIGS. 1-5. FIG. 1. Hind coxa (posterolateral view) of *F. conspicua* showing position of pv bristles. FIGS. 2 and 3. Hind femora (anterior view) of *F. conspicua* male and female respectively. FIGS. 4 and 5. Same for *F. thelazioe* male and female respectively.

Hypopygium.—(Figs. 6, 7). Cercal plate simple, divided basally, but fused apically, slightly elongate, bristling weak. Surstylus broad and simple, elongate and parallel-sided, without swelling at base in side view. Baciliform process strongly spiraled, heavy.

FEMALE: Head.—Parafrontals brownish gray pollinose, wider than frontal vitta and convex along inner margin. Setulae uniserial, extending down onto parafacials well below arista base. Third antennal segment entirely brown or very narrowly yellow at base. Palpus bright yellow, distinctly spatulate. Otherwise as in the male.

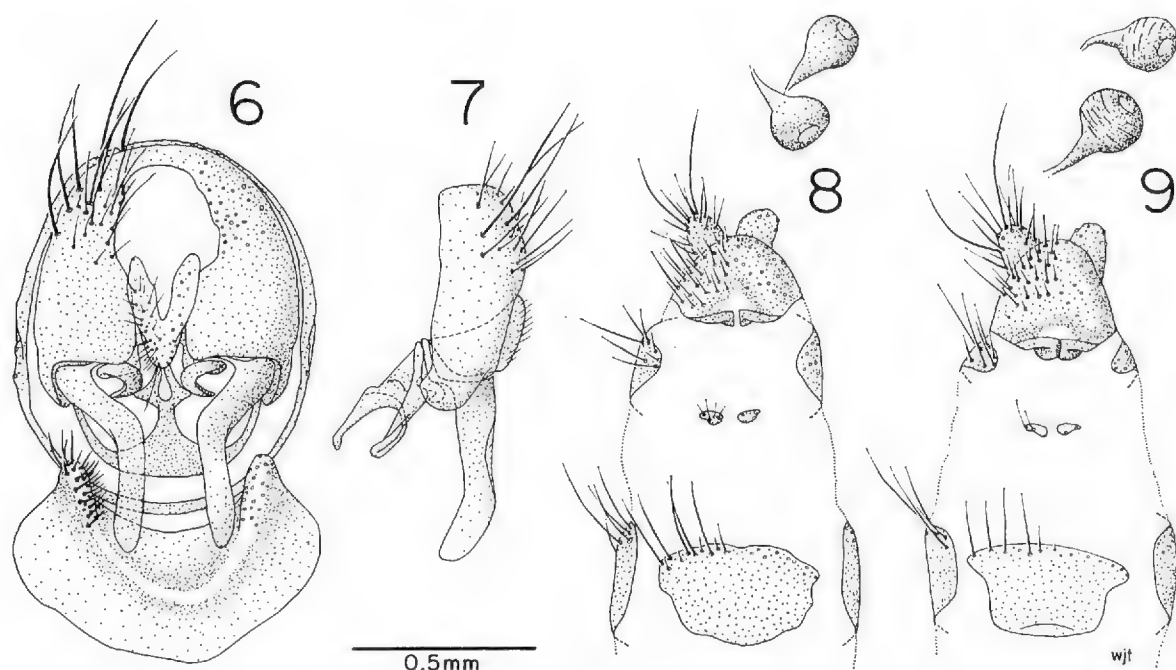
Thorax.—Distinctly gray to faintly brownish gray pollinose with single indistinct narrow brown vitta along acr row, lateral vittae present only as spots about bases of dc bristles and irregular brown markings around the intraalar row. Scutellum with two small, indistinct brown spots subbasally. Squamae with concolorous margins.

Abdomen.—Integumental color distinctly yellow on basal half of second and usually on third segment of abdomen, remainder gray pollinose with discontinuous median vitta and large brown lateral spots. Spermathecae two (Fig. 8).

Legs.—Yellowish brown. F_1 pvs evenly decreasing to base. F_2 avs and pvs with weak suberect setulae. T_2 medially with one each av, ad, pv and p subapical bristles, all subequal to tibial diameter, and 0-2 weak pvs. F_3 (Fig. 5) avs and pvs setulose except for two stronger preapical avs; T_3 ads and avs 1-2, limited to one median bristle each, two d bristles longer, one median and one subapical.

TYPE MATERIAL.—Holotype: Male, Hastings Reservation, Monterey County, California; laboratory reared from egg of female captured 18-IX-1969 (C. J. Weinmann). Allotype female, same data as holotype.

Paratypes, 368 ♂♂, 212 ♀♀. CALIFORNIA: Russelmann Park (nr. Mt. Diablo), Contra Costa County, 2 ♀♀ 10-IX-1969 (P. Rubtsoff); 17 ♂♂, 4 ♀♀, laboratory reared from eggs of females captured 10-IX-1969. University of California, Hopland Field Station (4 mi. east of Hopland), Mendocino County, 5 ♀♀ (11-18)-IX-1969 (D. Westrom), 1 ♀ 2-VI-1970, 1 ♀ 9-X-1969, 2 ♀♀ 22-X-1969, 1 ♀ 29-VI-1970, 1 ♀ 14-VII-1970 (P. Rubtsoff); 3 ♂♂, 2 ♀♀ laboratory reared



FIGS. 6-9. FIG. 6. Male hypopygium (posterior view) of *F. thelaziae*. FIG. 7. Same in profile. FIG. 8. Female postabdomen (ventral view) and spermathecae of *F. thelaziae*. FIG. 9. Same for *F. conspicua*.

from eggs of females collected (11-18)-IX-1969. Hastings Reservation, Monterey County, 42 ♀♀ 18-IX-1969, 7 ♀♀ 13-VIII-1970, 2 ♀♀ 22-IX-1970 (C. J. Weinmann); 347 ♂♂, 156 ♀♀ laboratory reared from eggs of females collected 18-IX-1969. Guerneville, 5.5 mi. E., Sonoma County, 1 ♀ 9-IX-1970 (P. Rubtsoff); 1 ♂, 1 ♀ laboratory reared from eggs of female captured 9-IX-1970.

Holotype, allotype and 10 paratypes deposited in the California Academy of Sciences, San Francisco. Additional paratypes have been placed in the American Museum of Natural History, New York; British Museum (Natural History), London; California Department of Public Health, Bureau of Vector Control, Berkeley; Canadian National Collection, Ottawa; Florida State Collection of Arthropods, Gainesville; Oregon State University, Corvallis; United States National Museum, Washington D.C.; University of California, Berkeley; Washington State University, Pullman; and Zoological Museum, Copenhagen.

Males of this species possess characters intermediate between several recognized species in the *benjamini* subgroup. In the male, the dark brown mesoscutum of *F. thelaziae* is typical only of *F. benjamini* while the yellowed abdomen and leg bristles suggest some similarity to *F. arizonensis*. Both *F. thelaziae* and *F. arizonensis* have several features of male genitalia in common, including the basic outline of the dististylus and the strongly curved bacillus process. In fact, the dististylus of *F. thelaziae* differs from that of *F. arizonensis* only in the absence of the basal swelling.

All females of the *benjamini* subgroup appear quite similar to each other, except perhaps to *F. benjamini* itself which lacks the typical yellow lateral markings at the base of the abdomen. In *F. conspicua* the mark-

ings are present but appear yellowish gray and are sometimes quite difficult to see. *Fannia thelaziae* females most closely resemble females of *arizonensis*. The spermathecae are similar in shape, size and structure in both species.

Both sexes of *F. thelaziae* lack posteroventral bristles on the hind coxae although they are present in all other species included in the *benjamini* subgroup by Chillcott. Even though lacking these bristles, *F. thelaziae* is retained in the *benjamini* group on the basis of its color pattern in both sexes, and the structure of the male genitalia and female spermathecae. Chillcott suggested an affinity between the *benjamini* and *pretiosa* groups. This latter group is characterized in part by unbristled metacoxae. The absence of these bristles in *F. thelaziae* would seem to strengthen the association of these groups.

As this species has now been incriminated as the vector of the mammalian eyeworm, *Thelazia californiensis* (Weinmann, *et al.*, 1974), the name *F. thelaziae* seems most appropriate.

ADULT SEASONAL ACTIVITY.—Collecting dates extend from 2 June to 22 October. Most specimens taken in the field were captured in early to mid September.

DISTRIBUTION.—Although collection records of this species are limited, the species appears to occur primarily at the margins of oak woodland areas of the San Francisco Bay Area and in adjacent counties from Mendocino County in the north to Monterey County in the south. At each locality sampled, *F. thelaziae* was sympatric and synchronic with both *F. benjamini* and *F. conspicua*.

FANNIA CONSPICUA Malloch

(Figs. 1-3 and 9)

Fannia conspicua Malloch, 1913: 624.

FEMALE: *Head*.—Parafrontals brownish gray pollinose, about as wide as frontal vitta and convex on inner margin. Parafrontals tending to silvery gray; setulae uniserial, extending down onto parafacials well below arista base. Oral membrane yellowish brown often making the oral margin beneath antennae appear yellowish. Third antennal segment broadly yellow at base, especially along inner ventral margin; base of arista yellowish. Palpus bright yellow, distinctly spatulate.

Thorax.—Gray pollinose, with faint narrow brown median vitta; lateral vitta reduced to dark brown spots about the bases of strong dcr bristles and irregular markings in intraalar rows. Scutellum with two more or less distinct brown spots subbasally. Squamae and their margins concolorous.

Abdomen.—Basal two or three segments faintly yellowish gray becoming gray laterally and on distal half or entirely gray with no hint of yellow coloration; remainder of abdomen gray pollinose with discontinuous brown median and large brown sublateral spots. Spermathecae two (Fig. 9).

Legs.—Yellowish to brownish yellow; base of F_1 brownish, tarsi black, pvs strong apically, evenly decreasing to base. F_2 avs and pvs present as regular, weak and suberect setulae; T_2 medially with one each av, ad, pd and subapical d, all subequal to tibial diameter, and 0–2 pvs appearing shorter and weaker. F_3 (Fig. 3) avs and pvs reduced to setulae except for two or three stronger preapical avs; T_3 avs 1 or 2, ads one median subequal to tibial diameter, d two, stronger and definitely longer than tibial diameter.

Malloch (1913) described *F. conspicua* from a single male specimen taken at Williams, Arizona. Females of this species are similar to most other females included in the *benjamini* subgroup. They are most easily recognized by their particular leg bristle patterns cited in the key. The yellow sublateral markings at the base of the abdomen in this species are quite variable. They are usually apparent in most specimens but in a significant number the color tends to yellowish gray and the marks appear restricted to the extreme lateral margins where they are very difficult to see. In still others the basal segments are entirely gray. In these latter individuals the yellow on the base of the third antennal segment, as is characteristic of *F. conspicua*, appears extensive and nearly always includes the base of arista. These specimens then, while looking much like females of *F. benjamini*, may be recognized by this antennal character.

ADULT SEASONAL ACTIVITY.—California records of *F. conspicua* range from 14 July to 29 October. A single Arizona record (no collecting date for the type is given) cited by Chillcott (1960) is considerably earlier (12 April).

DISTRIBUTION.—Chillcott (1960) recorded the species from Arizona and cited but two records, the type locality and Tempe. Since his study this species has been collected at a few locations in northern and central California, in particular Mendocino, Contra Costa and Monterey Counties. *Fannia conspicua* will probably be discovered at a number of localities between the extremes of its present known distribution.

MATERIAL EXAMINED.—CALIFORNIA: Russelmann Park (nr. Mt. Diablo), Contra Costa County, 2 ♀♀ 29-VII-1969, 1 ♀ 10-IX-1969 (P. Rubtsoff); 1 ♀ laboratory reared from egg of female captured 10-IX-1969. Hopland University of California, Hopland Field Station (4 mi. east of Hopland), Mendocino County, 5 ♀♀ (11–18)-IX-1969, 3 ♀♀ 25-IX-1969, 4 ♀♀ 30-IX-1969 (D. Westrom), 3 ♀ 29-X-1969, 1 ♂, 1 ♀ 14-VII-1970, 1 ♀ 21-VII-1970 (P. Rubtsoff); 12 ♂♂, 56 ♀♀ laboratory reared from eggs of females captured (11–18)-IX-1969, Hastings Reservation, Monterey County, 4 ♀♀ 18-IX-1969 (C. J. Weinmann); 124 ♂♂, 204 ♀♀ laboratory reared from eggs of females captured 18-IX-1969.

Female specimens of *F. conspicua* have been placed in the American Museum of Natural History, New York; California Academy of Sciences, San Francisco; British Museum (Natural History), London; California Department of Public Health, Bureau of Vector Control, Berkeley; Canadian National Collection, Ottawa; Florida State Collection of Arthropods, Gainesville; Oregon State University, Corvallis; United States National Museum, Washington, D.C.; University of California, Berkeley; Washington State University, Pullman; and Zoological Museum, Copenhagen.

KEY TO NEARCTIC SPECIES OF THE *FANNIA BENJAMINI* SUBGROUP
(modified from Chillcott, 1960)

1. Eyes contiguous or nearly so (males) 2
Eyes distinctly separated (females) 8
2. Thorax dark brown pollinose, not noticeably vittate 3
Thorax clearly vittate 4
3. Abdomen dark gray with pollen basally; third antennal segment black;
C₃ pvs present (California) *benjamini* Malloch
Abdomen yellow laterally on basal segments; third antennal segment yellow
narrowly at base, rarely all black; C₃ pvs absent (California)
..... *thelaziae* n. sp.
4. F₃ avs with a distinct cluster of longer bristles medially, only one strong
preapical bristle (Fig. 2) 5
F₃ with two to four strong preapical avs, no strong avs medially 6
5. F₃ avs and pvs at least as long as femoral diameter where situated (Ari-
zona, California) *conspicua* Malloch
F₃ av and pv bristles distinctly weaker, the pvs never as long as femoral
diameter (New Mexico) *neotomaria* Chillcott
6. F₃ with four strong preapical avs (California) *operta* Chillcott
F₃ with two (rarely three) strong preapical avs 7
7. F₃ with four to six strong pvs forming a tight cluster which does not grade
into setulae basad (Arizona) *tescorum* Chillcott
F₃ with four or five slender pv bristles in loose cluster continued basad
as erect setulae (Arizona) *arizonensis* Chillcott
8. Basal abdominal segments dark, overlaid with gray pollinosity 9
Basal abdominal segments yellowish, at least yellowish gray laterally;
if abdomen is entirely gray, then arista yellowish basally 10
9. Femora largely infuscated; thorax mostly dark brown (California)
..... *operta* Chillcott
Femora mostly yellowish; thorax gray pollinose (California)
..... *benjamini* Malloch
10. C₃ without pv bristles; third antennal segment yellow narrowly at base,
arista entirely dark (California) *thelaziae* n. sp.
C₃ with one or two pvs (Fig. 1); arista and third antennal segment
broadly yellow basally 11
11. T₂ median bristles longer than tibial diameter (Arizona) --- *tescorum* Chillcott
T₂ median bristles equal to or shorter than tibial diameter 12
12. Basal abdominal segments 2-4 distinctly yellowish (Arizona)
..... *arizonensis* Chillcott
Abdominal segment 2 and usually 3 yellowish, color often very indistinct
or tending to yellowish gray and confined to lateral areas; segment 4 gray
(Arizona, California) *conspicua* Malloch

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ZOOLOGICAL NOMENCLATURE

The following Opinions recently published by the Commission may be found by referring to the indicated volume of the Bulletin of Zoological Nomenclature.

- 1038 *Argiope* Audouin, 1826 and *lobata*, *Aranea*, Pallas, 1772, placed on Official Lists (Arachnida, Aranes). Vol. 32(2):105.
- 1039 Type-species of *Uloma* Dejean, 1821 (*Tenebrio culinaris* Linnaeus, 1758) and of *Phaleria* Latreille, 1802 (*Tenebrio cadaverinus* Fabricius, 1792) designated under the plenary powers; these names, with *Alphitobius* Stephens, 1829 and *Gnatocerus* Thunberg, 1814, and the names of their type-species, placed on Official Lists (Coleoptera). Vol. 32(3):136.
- 1042 *Deuterosminthurus* Börner, 1901; *Smynthurus bicinctus* Koch, in Herrich-Schaeffer, 1840 designated as type-species under the plenary powers (Collembola). Vol. 32(4):212.
- 1043 *Eusminthurus* Börner, 1900; *Podura viridis* Linnaeus, 1758 designated as type-species under the plenary powers (Collembola). Vol. 32(4):214.
- 1049 *Macgillivraya* Grote, 1894 suppressed under the plenary powers; *Friesea* von Dalla Torre, 1895 (type-species *Triaena mirabilis* Tullberg, 1871) placed on Official List (Collembola). Vol. 32(4):235.
- 1050 *Pediculus eurysternus* Burmeister, 1838 suppressed under the plenary powers; *Solenopotes* Enderlein, 1904 (type-species *S. capillatus* Enderlein, 1904) and *eurysternus*, *Haematopinus*, Denny, 1842, placed on Official Lists (Anoplura). Vol. 32(4):238.
- 1051 *Rhopalidia* Lepeletier, 1836 suppressed under the plenary powers (Hymenoptera). Vol. 32(4):240.
- 1053 *Formica maxima* Moore, 1842, suppressed under the plenary powers (Hymenoptera). Vol. 32(4):244.
- 1054 *Crinocerus* Burmeister, 1835; *Cimex sanctus* Fabricius, 1775, designated as type-species under the plenary powers (Hemiptera). Vol. 32(4):246.

The Commission cannot supply separates of Opinions.—R. V. MELVILLE, *Secretary, International Commission on Zoological Nomenclature.*

A New Species of Brine Fly From California Rice Fields

(Diptera: Ephydriidae)

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In my 1971 revision of the North American brine flies (Genus *Ephydra* Fallén) I gave a number of California records of what I had determined as the Palaearctic species, *Ephydra macellaria* Egger. More recently (Wirth, 1975) I have revised the Old World species of *Ephydra* and have more closely studied the *macellaria* complex. *Ephydra macellaria* Egger proves to be a seacoast species widely distributed in northern and western Europe; whereas the Old World rice field species breeding in habitats of fresher water as well as salt water is *E. helwanensis* Steyskal, described from Egypt and very common and widespread in the Mediterranean area.

The California species is closely related and very similar to *E. macellaria* and *helwanensis*, as redescribed by Wirth (1975), but with distinct genitalic differences. My 1971 description and figures are adequate to characterize the species, and I need merely at this time to indicate how it may be distinguished from *macellaria* and *helwanensis*.

***Ephydra usingeri*, new species**

Ephydra macellaria Egger; Wirth, 1971: 364 (misident.; description and figures; California records).

Resembles *Ephydra macellaria* Egger and *helwanensis* Steyskal in its heavily pollinose body, only slightly shiny, with more of a grayish tinge on the sides; legs yellowish with femora somewhat olivegreen infuscated; setae of body and legs rather large; prescutellar area of female with a low hump bearing a group of longer acrostichal setae. Aedeagus with apex slender and rounded in lateral profile, the anterior membranous lobe with strong ridges only proximally, the recurved basal process about half as long as straight portion. Surstyli stout basally, tapering with rounded tips distally; without distinct sclerotized carina or concavity, with fairly numerous scattered fine hairs except on dorsal side at apex. Gonite with apex bearing 3 distinct lobes. Fifth tergum with short, stout, anteroventral sclerotized process. Sternal plate strongly sclerotized and with very strong transverse ridgelike folds, the whole angularly bent ventrally in middle, forming a strongly serrate ventral process in genital pouch.

Differs from the two related species as follows: Male surstyli less triangular in ventral profile and less pointed distally than in *helwanensis*, the tips rounded but not constricted subapically as in *macellaria*. Gonite nearly as in *helwanensis*,

¹ Mailing Address: c/o U.S. National Museum, Washington, D.C. 20560

the rounded distal lobe not as prominent as in *macellaria*. Sternal plate with large coarse transverse accordianlike pleats nearly as in *macellaria*, but usually deeply folded into genital pouch, not forming as strong a process as in *helwanensis*. Length, 4 mm.

Holotype, male, allotype, TRACY, SAN JOAQUIN CO., CALIFORNIA, 1 June 1951, J. W. MacSwain (deposited in California Academy of Sciences, San Francisco). Paratypes, 21 males, 30 females, as follows: CALIFORNIA: Kings Co., Tulare Lake, 17 March 1931, E. P. VanDuzee, 4 males, 3 females. San Joaquin Co., Tracy, same data as types, 12 males, 8 females. Stanislaus Co., Westly, 1 June 1949, H. H. Keiffer, collected from rice (California Dept. Agr.), 2 females. Yolo Co., Davis, 30 April, 20-31 May 1960, F. E. Strong, 5 males, 17 females (Davis) Paratypes in collections of USNM, California Academy of Sciences, California Insect Survey in Berkeley, California Department of Agriculture in Sacramento, and University of California at Davis.

The species is named for my teacher and good friend at the University of California in Berkeley, the late Dr. Robert L. Usinger, in tribute to his leadership in the study of aquatic insects in North America, and especially in his home state of California.

From the Stanislaus County collection from rice, and from the nature of the California distribution records, it appears that *E. usingeri* is a distinctly freshwater species that may be associated with rice culture.

LITERATURE CITED

- WIRTH, W. W. 1971. The brine flies of the genus *Ephydra* in North America (Diptera: Ephydriidae). *Ann. Entomol. Soc. Amer.*, 64: 357-377.
WIRTH, W. W. 1975. A revision of the brine flies of the genus *Ephydra* of the Old World (Diptera: Ephydriidae). *Entomol. Scand.*, 6: 11-44.
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RECENT LITERATURE

- FLOWERING PLANTS. EVOLUTION ABOVE THE SPECIES LEVEL. G. L. Stebbins. Belknap Press, Harvard University, 1975. 399 pp., 13 tables, 59 figs. (\$18.50, hardcover).
THE SOCIAL BEHAVIOR OF THE BEES. C. D. Michener. Belknap Press, Harvard University, 1974. 464 pp., figs. (\$25.00, hardcover).

Additions to the Crane flies of California

(Diptera: Tipulidae)

CHARLES P. ALEXANDER

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The volume entitled "The Crane Flies of California" by the present author, was published in 1967 by the University of California Press.¹ Somewhat more than 450 species were included, and during the intervening period, numerous collections from the state have been studied and additions to the list have been made. At this time I am describing a few further species that were collected by Donald G. Denning, have added the additional species that were made to the basic list during this period, and have indicated two important changes in species names. I wish to thank Doctor Denning for the many crane flies that he has sent to me in the past that included several records of special importance.

***Rhabdomastix* (*Sacandaga*) *brevicellula*, new species**

General coloration of head and thorax light yellow, praescutum and scutum patterned with light brown; wings with abundant trichia on vein R_4 ; veins R_{1+2} and R_3 approximated at costa, the distance between them about one-third vein R_3 ; cell 1st M_2 unusually short and broad, the second section of vein M_{1+2} about one-fifth longer than the cell width.

Male.—Length about 5.5 mm.; wing 6 mm. Rostrum and antennal scape clear light yellow; palpi broken. Antennae with pedicel and flagellum black, proximal flagellar segments subglobular to short-oval, outer segments progressively more oval; outer segments with a single elongate verticil that is longer than the segment. Head clear light yellow.

Pronotum clear light yellow, narrowly pale brown medially. Mesonotal praescutum light yellow, with four light brown stripes, the intermediate pair nearly confluent, ending some distance before the suture; posterior sclerites yellow, each scutal lobe with two confluent light brown areas, posterior half of postnotal mediotergite similarly light brown. Pleura light yellow, ventral sternopleurite and meron broadly light brown. Halteres yellow. Legs with coxae yellow, fore pair slightly darker; trochanters yellow; remainder of legs broken. Wings light yellow, without darkened pattern; veins very pale brown. Macrotrichia on R and outer longitudinal veins, including about 20 over the whole length of R_4 ; veins R_5 , 2nd and outer sections of M_{1+2} , M_3 and M_4 with complete series of trichia; very sparse scattered trichia on outer section of Cu_1 and outer ends of both Anal veins, 1st A with a single trichia, 2nd A with two or three. Venation (Fig. 1) as shown; Sc_1

¹ Alexander, C. P. The Crane Flies of California. Bulletin of the California Insect Survey. Volume 8, pp. 269; 524 figures, 1 plate, 106 maps. University of California Press, Berkeley; November 27, 1967.

ending about opposite two-thirds to three-fourths R_s ; distance on costa between veins R_{1+2} and R_3 about one-third the latter vein; cell *1st* M_2 unusually short and broad, as shown, the second section of M_{1+2} about one-fifth longer than the breadth of the cell.

Abdomen, including hypopygium, chiefly yellow, faintly patterned with brown, more evident on outer segments. Male hypopygium (Fig. 4) as shown.

Holotype male, CALIFORNIA, MONTEREY COUNTY, Highway 128 at NORTH FORK of NARRARO RIVER, July 6, 1975 (D. G. Denning).

The most similar regional species is *Rhabdomastix* (*Sacandaga*) *trichophora* Alexander (California, Oregon, Washington) which similarly has trichia on vein R_4 of the wings, differing from the present fly most evidently in venation, including the wide separation of veins R_{1+2} and R_3 at costa and the longer cell *1st* M_2 .

***Hesperoconopa anthracina*, new species**

General coloration of entire body black, certain areas more pruinose; halteres brownish black, base of stem restrictedly yellowed; legs black; wings strongly darkened throughout, stigma not differentiated; abdomen black, sternites slightly more pruinose.

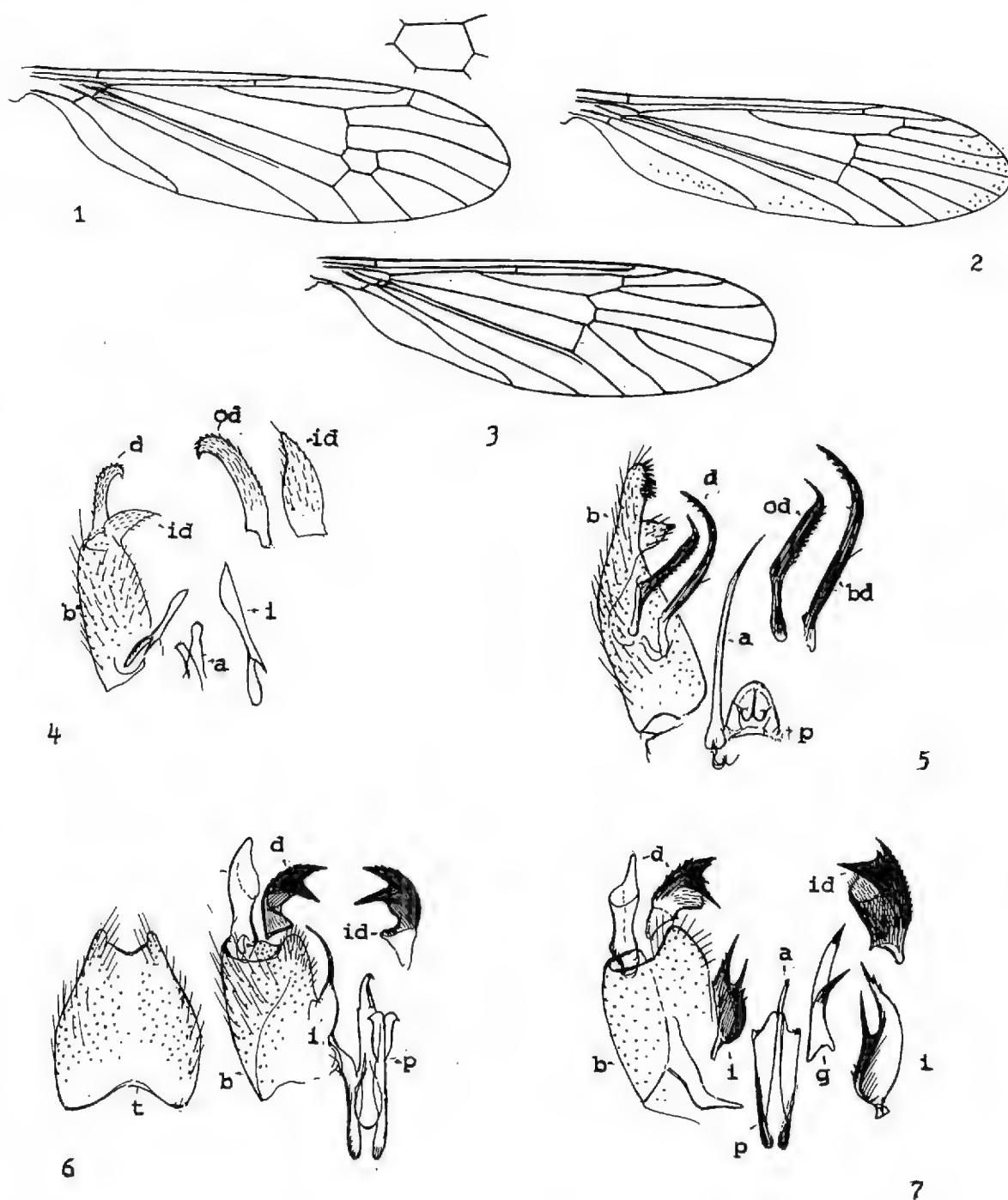
Female.—Length about 5.3 mm.; wing 5.8 mm.; antenna about 1.1 mm. Rostrum and palpi black. Antennae black; flagellar segments subcylindrical, ends truncated, subequal in length to the longest verticils. Head brownish gray; eyes small; anterior vertex broad.

Thorax dull black, praescutum with vague still darker stripes, central area of scutum and the scutellum slightly more pruinose. Pleura dark gray, ventral sclerites slightly more darkened. Halteres brownish black, base of stem restrictedly yellowed. Legs with coxae and trochanters black, slightly pruinose; remainder of legs black. Wings (Fig. 2) strongly darkened throughout, stigma not differentiated; narrow whitened lines over veins M , M_{1+2} , M_{3+4} and *1st* A ; veins light brown, Sc , R , M_3 and Cu darker. Outer wing cells from R_3 to M_3 with scattered trichia punctures, with further series in cells *1st* A and *2nd* A as indicated in the figure. Venation as shown; R_{2+3} about one-half longer than R_2 ; $m-cu$ at fork of M .

Abdomen blackened, sternites slightly more pruinose. Ovipositor with cerci slender, outer ends slightly upcurved.

Holotype, female, CALIFORNIA, EL DORADO COUNTY, SOUTH FORK OF AMERICAN RIVER, July 17, 1975 (D. G. Denning).

Generally similar to *Hesperoconopa melanderi* (Alexander), likewise from California, differing chiefly in the darker body coloration and especially the more blackened wings. I believe that the male sex when discovered will provide further hypopygial differences. The very distinct aquatic immature stages of *Hesperoconopa* have been described and figured by C. Dennis Hynes (Pan-Pacific Entomologist, 44: 324–327, 4 figs.; 1968).



FIGS. 1-7. Fig. 1. *Rhabdomastix (Sacandaga) brevicellula* sp.n.; venation. Fig. 2. *Hesperoconopa anthracina* sp.n.; venation. Fig. 3. *Ormosia (Ormosia) denningi* sp.n.; venation. Fig. 4. *Rhabdomastix (Sacandaga) brevicellula* sp.n.; male hypopygium. Fig. 5. *Molophilus (Molophilus) spiniapicalis* sp.n.; male hypopygium. Fig. 6. *Ormosia (Ormosia) denningi* sp.n.; male hypopygium. Fig. 7. *Ormosia (Ormosia) loretta* sp.n.; male hypopygium.

Symbols: *a*, aedeagus; *b*, basistyle; *bd*, basal dististyle; *d*, dististyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *t*, tergite.

Molophilus (Molophilus) spiniapicalis, new species

Allied to *distilobatus*; general coloration of thorax light brown, abdomen dark brown; legs with femora yellow, tarsi brown; male hypopygium with mesal lobe of basistyle long-extended, narrowed outwardly, the aggregation of blackened spinoid setae opposite or beyond the apices of the dististyles, the subtending lobe broad, with numerous setae.

Male.—Length about 4–4.3 mm.; wing 4.5–5.2 mm. Rostrum and palpi black. Antennae (broken at fifth segment) with scape and pedicel obscure yellow, flagellum black; flagellar segments oval, more elongate outwardly, verticils long. Head blackened, gray pruinose.

Pronotum and pretergites light yellow. Mesonotal praescutum light brown, humeral region vaguely more yellowed; scutum brown, scutellum obscure yellow; postnotum dark brown to brownish black. Pleura yellowish brown to dark brown, dorsopleural region still darker. Halteres with stem yellow, knob light brown, apex more yellowed. Legs with coxae and trochanters yellow; femora yellow, tibiae more obscure yellow, tarsi brown. Wings with prearcular and costal fields light yellow, including the veins, remainder more whitish gray; veins brown, trichia black.

Abdomen dark brown. Male hypopygium (Fig. 5) generally as in *distilobatus*, differing in details, especially of the basistyle. Mesal lobe of basistyle, *b*, long-extended and narrowed, the aggregation of blackened spinoid setae lying opposite or beyond the apices of the dististyles, the subtending lobe broad, with numerous setae. Aedeagus, *a*, long and slender, extended into a long spine.

Holotype male, CALIFORNIA, MONTEREY COUNTY, PLASKETT CREEK CAMPGROUND, July 25, 1975 (D. G. Denning). Paratopotype, ♂. Paratype, ♂, California, without further data, August 22, 1966 (C. Dennis Hynes).

The most similar species is *Molophilus (Molophilus) distilobatus* Alexander (Washington to California). The distinctive male hypopygium of this is discussed and figured in the Crane Flies of California, p. 148, fig. 514.

Ormosia (Ormosia) denningi, new species

General coloration of head and thorax dark gray, mesonotal praescutum with a narrow dark brown median line; wings light brown, stigma darker brown; abdomen brownish black; male hypopygium with tergite large, narrowed outwardly to the shallowly concave apex; inner dististyle black, outwardly divided into two strong spines, the outer one slightly broader, the margin microscopically roughened; basistyle with interbase a simple long slender blackened spine.

Male.—Length about 6 mm.; wing 5.5 mm. Rostrum and palpi black. Antennae (male) broken at fourth segment, scape and pedicel light brown, flagellum black; proximal two flagellar segments elongate, broadest basally, narrowed to the outer end, the antenna when entire evidently relatively long. Head brownish gray.

Thorax almost uniformly dark gray, mesonotal praescutum with a narrow dark brown central line, behind almost attaining the suture. Halteres light brown, outer half of knob dark brown. Legs with coxae obscure yellow, trochanters somewhat clearer yellow; remainder of legs broken. Wings (Fig. 3) light brown,

stigma conspicuously darker brown, wing cells before the stigma slightly more yellowed; veins dark brown. Venation almost as in *burneyana*; left wing of type mounted on slide, with a long subterminal spur near outer end of vein R_4 , not reaching the margin, the right wing normal.

Abdomen brownish black, sparsely pruinose. Male hypopygium (Fig. 6) with the tergite, *t*, large, broadest across base, gradually narrowed outwardly to the shallowly concave apex, outer lateral angles produced into small pale oval lobes that are provided with abundant microscopic setae. Outer dististyle, *od*, simple, broadest at near midlength, narrowed outwardly into an obtuse point; inner style, *id*, distinctive, black, widened outwardly, divided into two strong spines, the outer one broader, microscopically roughened. Basistyle, *b*, with interbase, *i*, a simple long slender blackened spine, the base dilated.

Holotype male, CALIFORNIA, MONTEREY COUNTY, PLASKETT CREEK CAMPGROUND, July 25, 1975 (D. G. Denning).

I take pleasure in naming this interesting fly for Dr. Donald G. Denning, distinguished student of the Trichoptera, to whom I am indebted for many Tipulidae from the western United States. The nearest relative is *Ormosia* (*Ormosia*) *burneyana* Alexander, likewise from California, which differs chiefly in hypopygial structure, including the tergite, basistyle and inner dististyle. The male hypopygium of this species was figured in the California Bulletin, p. 144, fig. 481. The structure of the inner dististyle also is generally similar to that of the unrelated *Molophilus* (*Molophilus*) *fenderi* Alexander, also of western North America.

***Ormosia* (*Ormosia*) *loretta*, new species**

Antennae of male elongate; body dark brownish gray, abdomen dark brown; male hypopygium with the inner dististyle blackened, terminating in a major spine; basistyle with the interbase distinctive, with two long blackened spines; phallosome with gonapophysis bispinuous.

Male.—Length about 5.5 mm.; wing 6 mm. Rostrum and palpi black. Antennae broken beyond the fourth segment, elongate, if entire apparently extending to the wing root or slightly beyond, black; basal flagellar segments elongate, with very long erect setae, the longest nearly equalling the segment. Head dark gray.

Prothorax dark brownish gray. Mesonotal praescutum chiefly covered by four grayish brown stripes, interspaces scarcely indicated, each with a row of microscopic setigerous punctures; pseudosutural foveae and tuberculate pits black, conspicuous; posterior sclerites of notum dark brown. Pleura brownish gray, dorsopleural membrane light yellow. Halteres with stem obscure yellow, knob brownish black. Legs with coxae obscure yellow, bases of middle pair narrowly darkened; trochanters light yellow; remainder of legs broken. Wings light brown, cells basad of the dark brown stigma light yellow, beyond the stigma less evidently brightened; cells *C* and *Sc* slightly darker than the ground; veins dark brown. Venation: Sc_1 ending shortly beyond level of R_2 ; R_s straight, slightly longer than vein Sc_1 ; cell M_2 open by atrophy of M_3 ; *m-cu* shortly before fork of *M*; vein 2nd *A* with distal third slightly arcuated.

Abdomen dark brown. Male hypopygium (Fig. 7) with the important structures as shown. Inner dististyle, *id*, blackened, expanded outwardly, terminating in a long triangular point, with two smaller more dorsal spines. Basistyle, *b*, with a modified interbasal structure, *i*, as shown, terminating in an elongate spine with two microscopic spinules on outer margin, on inner face with a comparable long slender spine. Phallosome, *p*, including the small slender aedeagus and the gonapophyses, *g*, that appear as a straight yellow spine that bears a long black lateral rod at near midlength.

Holotype, ♂, California, Santa Cruz County, Watsonville, on Highway 152, August 1, 1975 (D. G. Denning).

I take pleasure in naming this species for Mrs. Donald Denning, Loretta. There are several allied and generally similar species in western North America that have been discussed and figured in the California Bulletin, such including *Ormosia* (*Ormosia*) *burneyana* Alexander, *O.* (*O.*) *burneyensis* Alexander, *O.* (*O.*) *denningi* sp.n., *O.* (*O.*) *legata* Alexander, *O.* (*O.*) *pleuracantha* Alexander, and some others.

SPECIES NEW TO CALIFORNIA LIST

Tipula (*Trichotipula*) *frommeri* Alexander. Great Basin Naturalist, 33: 189-192; 1973. California, Riverside County, Deep Canyon, Desert Research Center, May 15, 1969, Saul Frommer.

Tipula (*Trichotipula*) *sanctaecruzae* Alexander. Great Basin Naturalist, 33: 192-193; 1973. California, Santa Cruz Island, Channel Islands, 1941 (Eric Remington).

Tipula (*Lunatipula*) *hastingsae diperona* Alexander. Great Basin Naturalist, 33: 193; 1973. California, Santa Cruz Island, Channel Islands, University of California Research Station, Canada del Medio, April 1970 (Eric Remington).

Tipula (*Lunatipula*) *mecotrichia* Alexander. Great Basin Naturalist, 26: 2-3; 1966. California, Fresno County, Kings Canyon, June 1, 1963 (Alexander).

Dicranota (*Dicranota*) *bernardinensis* Alexander. Great Basin Naturalist, 24: 4; 1966, California, San Bernardino County, Thurman Flats, Mill River, May 1, 1963 (Alexander).

Dicranota (*Rhaphidolabis*) *nooksackensis* Alexander. American Midland Naturalist, 42: 300-301; 1949. Washington (type); Oregon, Alaska. California, Eldorado County, South Fork of American River, July 17, 1975 (Denning).

Dactylolabis (*Dactylolabis*) *postiana* Alexander. Pan-Pacific Entomologist, 20: 94-95; 1944. Oregon (types). California, Shasta County, March 31, 1968 (Denning).

Dactylolabis (*Eudactylolabis*) *vestigipennis* Alexander. Bull. Brooklyn Ent. Soc., 45: 45-46; 1950. Types from the Tucson Mountains, Pima County, Arizona, February and March 1937 (Owen Bryant). California, Los Angeles Co., February 10, 1967 (David Rentz); San Bernardino County, near Cajon Pass, at edge of Mohave Desert, March 1967 (Rentz). For a more detailed account, see Rentz and Gagné, Ent. News, 78: 261-262; 1967.

Idiognophomyia *enniki* Alexander. Pan-Pacific Entomologist, 50: 279-281, 3 figs.; 1974 (adult). George W. Byers, the same, 50: 282-287, figs. 1-15 (larva and pupa); 1974. Types from Ventucopa, western Ventura County, Los Padres

National Forest. Larvae and pupae were found by Dr. Franklin Ennik in decaying *Yucca* near U. S. Highway 399 on April 9, 1974.

CHANGES IN NAMES
(Trichoceridae)

Diazosma hirtipennis (Siebke) (1863)

Diazosma subsinuata Alexander; North American Catalogue, p. 15; 1965. Crane Flies of California, p. 13; 1967.

Diazosma hirtipennis Siebke; Christine Dahl, Opuscula Entomologica, 31: 97; 1966.

(Tipulidae)

Ormosia (*Ormosia*) *affinis* (Lundbeck)

Rhypholophus affinis Lundbeck; Diptera Groenlandica. Vidensk. Medd. nat. hist. Copenhagen, p. 266, plate VI, fig. 17 (wing); 1898.

Ormosia manicata (Doane), as *Rhypholophus*; Jour. N. Y. Ent. Soc., 8: 187; September 1900. See Bo Tjeder, 1970 Entomologiske Meddelelser, 38: 253–256, 4 figs. (male hypopygium) for detailed synonymy. Synonymy of *manicata* given by Alexander in California Bulletin, p. 145.

Changes in generic and subgeneric names.

Limnophila (*Euphylidorea*) Alexander, Ent. News, 83: 32; 1972.

Four species of *Limnophila* (*Phylidorea*) in Craneflies of California, p. 112, *aequiatra* Alexander, *brevifilosa* Alexander, *burdicki* Alexander, and *flavipila* Doane are transferred to the new subgenus *Euphylidorea*, cited above.

Erioptera (*Hespereriptera*) Alexander, Ent. News, 35–36; 1972, new subgenus for *Erioptera oregonensis* Alexander, California Bulletin, p. 135.

RECENT LITERATURE

RÉVISION DE LA TRIBU DES RHODOPININI GRESS. DE LA RÉGION ASIATO-AUSTRALIENNE (COLEOPTERA, CERAMBYCIDAE), PREMIÈRE PARTIE. S. Breuning. 70 pages plus 7 photographs on 2 plates, 21 cm × 30 cm page, spiral bound. "Imprimé en Xerocopie" by Sciences Nat, 45 rue des Alouettes, 75019 Paris. "Copyright: SCIENCES NAT 1975." Price about US \$10.

This publication provides a key and brief descriptions to the 75 genera (4 are new, with also 3 new subgenera) for the area considered. Keys are provided to the species if there is more than one included species in a genus. 231 species are briefly described, of which 12 are new. The 7 photographs mounted on 2 pages include illustrations of 3 Pic types.—PAUL H. ARNAUD, JR.

Life History of the Ragweed Plume Moth, *Adaina ambrosiae* (Murtfeldt), in Southern California

(Lepidoptera: Pterophoridae)

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Faunistic surveys of California ragweeds (*Ambrosia* spp., Compositae) detected numerous species of phytophagous insects associated with these native plants (Goeden and Ricker, 1974a, 1974b, 1975, 1976, and unpublished data). Many of these insects were little studied species of no economic importance. We have begun life history studies of the more stenophagous species, some for their intrinsic interest, others as candidate agents for the biological control of North American ragweeds accidentally introduced into eastern Europe and elsewhere, where they are becoming important agricultural and hayfever-inducing weeds (Goeden et al., 1974).

Adaina ambrosiae (Murtfeldt) was among the first species selected for more intensive study in the field and laboratory; however, it was found to reproduce readily on sunflower, *Helianthus annuus* L., and thus was rejected as a candidate biological control agent. Our observations on the life history of this heretofore little known plume moth are reported. Unless otherwise indicated, these data were obtained from cultures maintained in the insectary of the Division of Biological Control, Department of Entomology, University of California, Riverside. Insectary conditions were $27 \pm 1^\circ\text{C}$, 40–70% relative humidity, and a 12/12-hr (light/dark) photoperiod.

Taxonomy.—*Adaina ambrosiae* was described as a species of *Oidamatophorus* by Murtfeldt (1880). She included descriptions of the larva and pupa, which were quoted and amplified by Barnes and Lindsey (1921). The adult was illustrated in Barnes and Lindsey (1921) and Essig (1926).

Distribution and Host Plants.—Essig (1926, p. 714) described its range as “. . . throughout the United States, and in Arizona and along the Pacific Coast in the west.” He noted that the larvae feed on “ragweed.” Barnes and Lindsey (1921) reported this species from *Ambrosia artemisiifolia* L.

We collected *Adaina ambrosiae* larvae during January–October, 1969–71, from *Ambrosia acanthicarpa* Hooker, *A. chamissonis* (Lessing) Greene, *A. confertiflora* Decandolle, *A. dumosa* (Gray) Payne, *A. erio-*

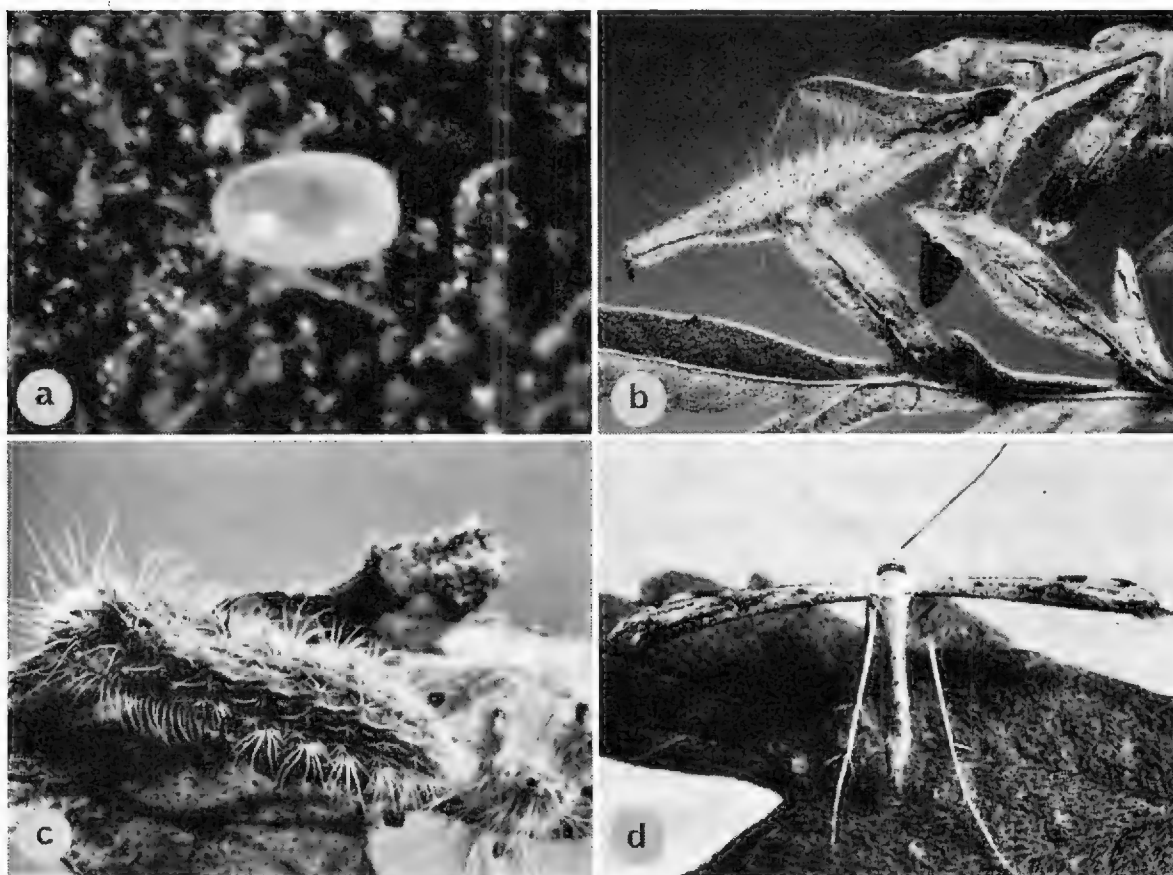


FIG. 1. Life stages of *Adaina ambrosiae*. (a) egg, 50 $\times$, (b) fifth instar larva that has fed on leaf of *Ambrosia confertiflora*, 2 $\times$, (c) pupa, 7 $\times$, (d) adult, 4 $\times$.

centra (Gray) Payne, and *A. psilostachya* Decandolle at the following locations in southern California: Los Angeles Co.—Azusa, Llano, South San Gabriel; Orange Co.—Huntington Beach, El Toro, Yorba Linda; Riverside Co.—Banning, Desert Center; San Bernardino Co.—Apple Valley, Bloomington, Cedar Canyon, Hackberry Mountain, Mountain Pass, Twenty-nine Palms; San Diego Co.—Chula Vista, Fallbrook, La Mesa, Piru, and Ventura. *Adaina ambrosiae* was most commonly and widely associated with western ragweed, *Ambrosia psilostachya*, on which it was cultured in the insectary. We also have collected the larvae from cocklebur, *Xanthium strumarium* L., on several occasions and reared them to adults on this weed.

Biology.—Egg.—The egg (Fig. 1a) is ellipsoidal, translucent white to pale yellow, smooth, and lustrous. The mean ($\pm$ S.E.) length and width of 50 eggs were 0.354 ± 0.002 mm and 0.237 ± 0.001 mm, respectively.

The positions of 220 eggs obtained from 5 moths were recorded. All were attached singly to leaf blades, one to several per leaf, their long axes parallel to the upper and lower leaf surfaces (Fig. 1a). Only 4 (1.8%) of these eggs were laid on the superior epidermis. Fifty-seven

(26%), 121 (56%), and 38 (18%) of the remaining 216 eggs were attached to the basal, middle, and apical thirds of the undersides of leaf laminae, respectively. Of the 220 eggs, 108 (49%) were laid alongside a midrib, 60 (27%) were laid in contact with a primary vein, 25 (11%) were laid next to a secondary vein, and the remaining 27 (12%) touched no veins. The incubation period was about 4 days.

Larva.—Twelve of 15 larvae individually reared from eggs passed through 5 instars in an average of 18 ± 0.8 days. Three larvae apparently molted only 3 times and pupated after 14, 15, and 15 days. The maximum lengths attained by the first to fifth instars were 1.15 ± 0.03 mm, 1.90 ± 0.03 mm, 3.06 ± 0.07 mm, 4.94 ± 0.03 mm, and 7.44 ± 0.07 mm, respectively. Larvae with 5 instars grew in length an average of 60% between each successive molt.

The newly hatched larva is pale yellow. After eclosion, it abandoned the chorion and immediately proceeded to feed on the leaf lamina, gradually assuming the pale green coloration characteristic of subsequent instars. All instars were leaf skeletonizers (Fig. 1b). They consumed the adjacent epidermis and mesophyll, forming irregularly shaped scars, but left intact the opposite epidermis, midrib, primary veins, and at least the bases of the secondary veins. First to third instars evidenced a slight preference for feeding upon the lower leaf surfaces. Fourth and fifth instars tended to feed more upon the upper leaf surfaces. The latter tendency was most pronounced in the last instar (Fig. 1b).

The larvae apparently fed most actively at night. In the field, later instars commonly rested by day in shallow grooves excavated the lengths of their bodies along the midribs on the upper sides of leaves. From these resting niches, in which pupation frequently occurred, the larvae apparently foraged by night to return and rest between feedings by day. Fine silken threads on the foliage marked the course of their movements. In the insectary, one or more stadia, sometimes the entire larval period, was spent on the same leaf. The first to fifth stadia averaged 3 ± 0.2 (range: 2–4) days, 2.6 ± 0.1 (range: 2–3), 2.3 ± 0.1 (range: 2–3), 3.5 ± 0.2 (range: 3–5), and 5.6 ± 0.2 (range: 5–7) days, respectively.

The later instars threw their small, dark, fecal pellets over their heads for distances of several cm by means of rapid upward flips of their terminal abdominal segments. This behavior kept their feeding areas relatively clean (Fig. 1b).

A non-feeding prepupal stage began 2 days prior to pupation, during which time the mature larva contracted slightly in length, took on a

violet hue, and spun a small silken pad upon the leaf surface. The prepupae turned whitish 1 day prior to pupation.

Pupa.—The pupa (Fig. 1c) is slightly angulate, hairy, and naked. It is attached posteriorly by a cremaster to the silken pad spun by the mature larva. When disturbed, the pupa bent its abdomen backward and arched upward anteriorly. The mean length of 118 pupae was 5.73 ± 0.03 mm.

Most pupation occurred atop leaf blades, although a few pupae were attached to the undersides of living or dead, lower cauline leaves. Some mature larvae vacated the plants and pupated on the walls and floors of cages. The pupal periods for 55 individuals averaged 5.5 ± 0.1 (range: 2–8) days.

Adult.—Adults were not commonly encountered in nature. They mostly remained at rest on plants by day, their wings characteristically outstretched (Fig. 1d), flying short distances when disturbed.

When caged with bouquets of freshly excised, vegetative shoots and provided with water, 11 fecund females lived an average of 11.8 ± 1.1 (range: 7–17) days; 15 males averaged 10.7 ± 1.1 (range: 6–22) days. After a preovipositional period that averaged 2.8 ± 0.3 (range: 2–5) days, these 11 females oviposited for an average of 8.5 ± 1.1 (range: 4–15) days. During these ovipositional periods, they laid an average total of 119 ± 26 (range: 38–283) eggs. The daily numbers of eggs produced by these females varied considerably. Based only on days when females oviposited, the daily totals varied from 1 to 67 eggs and averaged 14.4 ± 1.4 eggs. Oviposition rates sharply declined toward the ends of the oviposition periods. Oviposition apparently occurred only at night.

Mating and dispersal normally were nocturnal activities, although 4 instances of mating were observed during daylight hours in the morning and afternoon for protracted, but untimed durations.

Of 109 adults reared from a random sample of insectary-reared F_1 generation pupae derived from field-collected larvae, 52 were females and 57 males.

Seasonal History.—*Adaina ambrosiae* is multivoltine in southern California; however, the number of annual generations is unknown and probably varies considerably with the host plant species and climatic zone involved. In the insectary, the egg to egg cycle was completed in about 30 days.

Natural Enemies.—Field collected larvae commonly were heavily parasitized. *Apanteles* sp. nr. *nemoriae* Ashmead (Hymenoptera: Braconidae) was reared from larvae collected from *Ambrosia confertiflora*

and *A. psilostachya*. *Hyposoter* sp. nr. *nigrolineatus* (Viereck) (Hymenoptera: Ichneumonidae) was reared from larvae collected on *A. confertiflora*, *A. dumosa*, *A. eriocentra*, and *A. psilostachya*. Both were primary, solitary endoparasitoids. A single specimen of *Mesochoris* sp. (Hymenoptera: Ichneumonidae) was reared, probably as a hyperparasitoid, from a larva collected on *Ambrosia psilostachya*.

ACKNOWLEDGMENTS

Adaina ambrosiae was identified by Dr. D. C. Ferguson, Systematic Entomology Laboratory, U. S. Dept. Agric., Agric. Res. Serv., c/o U. S. National Museum, Washington, D. C. The parasitoids were identified by Dr. P. M. Marsh, same address.

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A New *Choreutis* from the San Francisco Bay Area, California

(Lepidoptera: Glyphipterygidae)¹

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Current revisionary work in the Glyphipterygidae³, of the Palearctic fauna by A. Diakonoff (Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands), of the Japanese fauna by Y. Arita (Meijo University, Nagoya, Japan), and of the Nearctic fauna by myself, has uncovered numerous taxonomic and nomenclatural problems at the species and generic level. Brock (1967) has indicated that the family may be polyphyletic, which may require the elevation of the two included subfamilies (Choreutinae and Glyphipteryginae) to family rank, but this requires further investigation in a world-wide generic revision.

The Holarctic genus *Choreutis* Hübner is heterogeneous as presently constituted in North America, necessitating some transfers to the long unused but distinct *Tebenna* Billberg. Various characters common to several western North American species currently in *Choreutis*, including the new species described below, also indicate that this species group may require a new genus. Species of *Choreutis* and *Tebenna* have been almost exclusively placed in the former genus or in *Simaethis* Leach. *Simaethis* is a junior synonym of *Anthophila* Haworth.

The new species described below, tentatively placed in *Choreutis*, was among material sent on loan from the California Insect Survey of the University of California, Berkeley. Biological studies by J. A. Powell (University of California, Berkeley) warrant a description of the species at this time. The specific name of the new species is derived from Greek translated as "from hound's tongue."

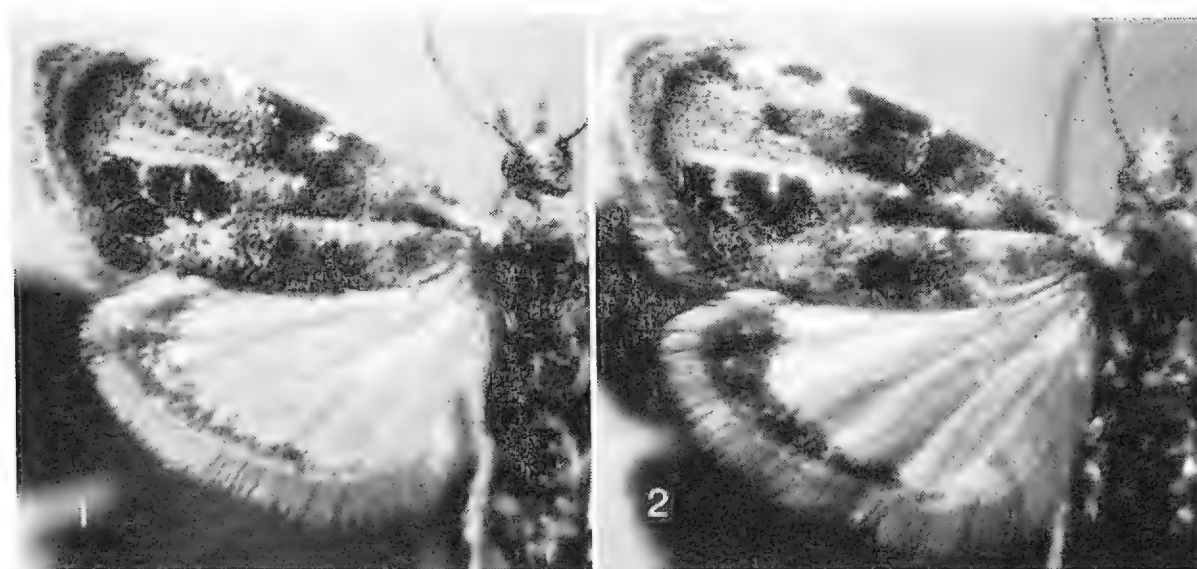
***Choreutis apocynoglossa*, new species**

Male (Fig. 1).—Forewing length 4.8 to 6.0 mm. *Head*: vertex with dense white-tipped, fuscous scales directed antero-mesad; frons similar in color. Labial palpus somewhat upturned, extended anteriorly nearly twice eye diameter; basal segment

¹ Florida Agricultural Experiment Station Journal Series No. 7013.

² Research Associate, Florida State Collection of Arthropods.

³ The International Commission on Zoological Nomenclature is considering a proposal by A. Diakonoff and myself for plenary power retention of the name Glyphipterygidae, rather than the spelling correction to Glyphipterigidae, and curtailment of the further use of *Glyphipteryx* Curtis for *Chrysoclista* in Blastodacnidae (case Z. N. (S.) 2115).



FIGS. 1-2. adults of *Choreutis apocynoglossa* Heppner: Fig. 1. holotype male; Fig. 2. allotype female.

white, tufted ventrally; 2nd segment subequal to 1st, fuscous with apical two scale rows white-tipped, tufted ventrally with fuscous and white scales as long as 2nd segment; apical segment half length of 2nd, white and fuscous. Antenna somewhat more than half forewing length; scape fuscous, remaining segments with alternating bands of dark fuscous and white; ventrally with setae (male sex character) twice length of antennal width. *Thorax*: dorsum white and fuscous intermixed. Patagia white ringed, fuscous centrally. Venter white. Legs white with some fuscous on fore- and midtibiae; tarsal segments basally fuscous, apically white. Spurs white, inner spurs near twice outer spur lengths. *Forewing*: length 2.5 greatest width; apex and tornus rounded; termen only slightly convex, oblique to tornus; costal margin and posterior margin convex; chorda weakly separated from cell; pterostigma well developed. Ground color dark fuscous, scales white-tipped. Basal fourth fuscous, some white-tipped scales, with a small patch of ochreous-tipped scales near base of radius. Antemedial fascia convex, distinctly dull white, scales basally dark fuscous. Wide median fuscous band; white spot on costal margin, followed diagonally toward tornus by silvered line ending at cubital border of cell, then interrupted before continuing to posterior margin, angled toward anal angle; upper silvered line surrounded by ochreous-tipped scales; two diffuse patches of black-fuscous scales near median on radius and anal vein. Post-medially of ground color; distal third with four diffuse, white longitudinal striae above black tornal mark (striae sometimes more or less merged); costal margin with white spot just beyond median and another at apical fourth of wing; metallic-silver scales on radius at median and near apical corner of cell; apical angle with fuscous curved line followed by metallic-silver curved line; distal linear yellow spot at apex. Tornal quarter with large black trapezoidal spot, interrupted distally beyond midpoint by vertical light yellow line, with metallic-silver spot in anterior half; a distal border of metallic-silver. Tornal angle fuscous, scales white-tipped, some yellow-tipped scales adjacent to metallic-silver border of large black spot. Fringe with basal row of fuscous, white-tipped scales, then fuscous to diffuse white outer margin of termen; longer and oblique at tornus. All metallic-silver spots elevated above wing surface due to convex scales. Ventrums with costal white

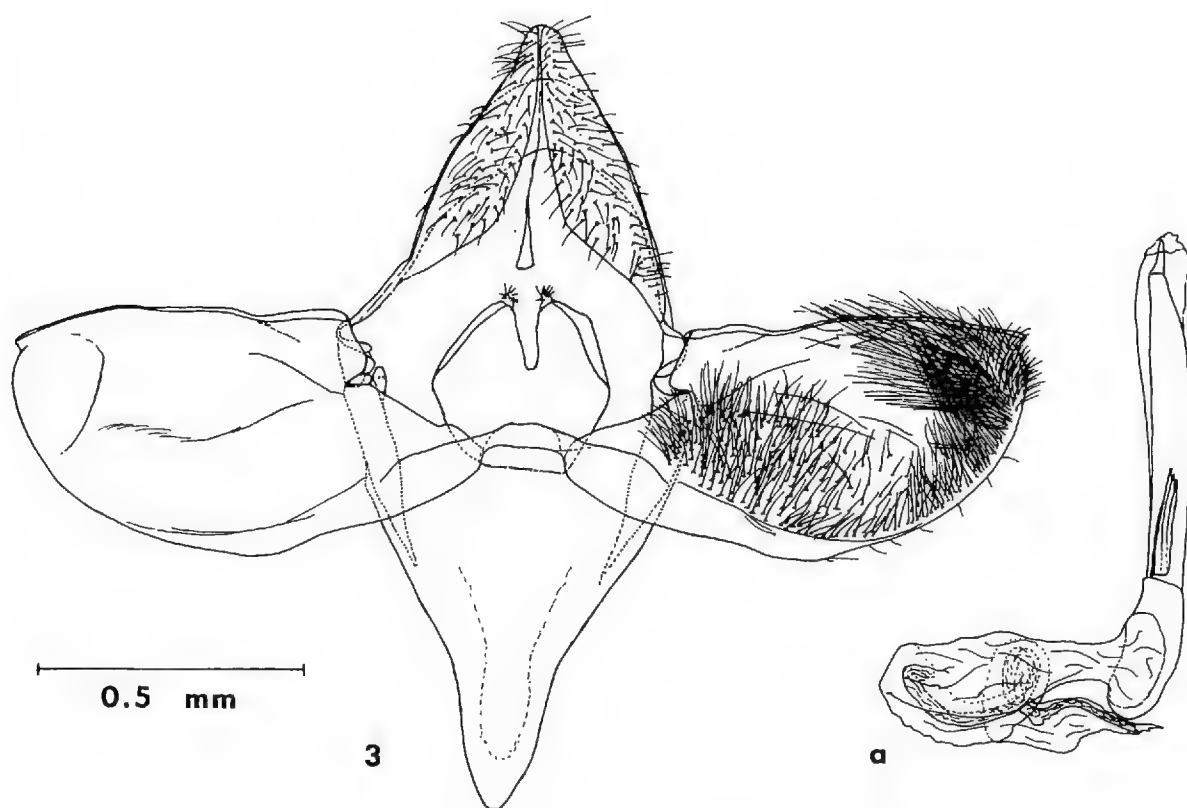


FIG. 3. male genitalia of *Choreutis apocynoglossa* Heppner holotype, ventral aspect; a, ventro-lateral aspect of aedeagus.

spots repeated; costal half of wing evenly fuscous; posterior half lustrous dull white to irregular border area with costal half; apex fuscous, extended as a fuscous terminal border to tornus. *Hindwing*: triangular, tornal margin broadly rounded; costal margin convex; ground color uniformly lustrous white except for some scattered fuscous scales at base (rarely in central white area); fuscous margin at termen; margin broader at apical angle, becoming narrow toward tornus. Fringe white, slightly brown and basally fuscous only at apical margin. Ventrums white; some fuscous at apical angle. *Abdomen*: fuscous and white ringed dorsally and ventrally, more white laterally, each segment anteriorly fuscous and posteriorly white. *Genitalia*: as in Fig. 3. Tegumen convex posteriorly, becoming a narrow band laterally. Socii large, well developed. Gnathos absent except for apparently vestigial and plate between socii. Juxta basally elongated to juncture with valval sacculus; lateral edges becoming thin. Valva dorso-laterally convex. Vinculum broadly convex. Aedeagus with 3-4 strongly sclerotized, flat, sharply pointed cornuti almost as long as phallobase length. Genitalia drawn from holotype (JBH prep. No. 255); 9 preparations examined.

Female (Fig. 2).—Forewing length 5.8 to 6.5 mm. As described for male, but with antenna lacking ventral setae; hindwing terminal fuscous border sometimes wider than in male; ventrum of forewing with less fuscous on termen than in male. *Genitalia* (Fig. 4): ovipositor lobes small, sharply edged, with many setae on sclerite anterior to lobes. Posterior apophyses longer than anterior apophyses; basally broad and flattened. Anterior apophyses with a broad flattened central area with a slight hook-projection ventro-laterally. Ostium round with broadened antero-ventral margin, bordered anteriorly by extensive setal field. Ductus bursae sclerotized, nearly as wide as ostium, becoming two times wider at enlarged, dis-

tinct offset juncture with bursal ventrum. Junction of ductus bursae and ductus seminalis at one-third ductus bursae length from ostium; ductus seminalis with oval bulla seminalis. Bursa copulatrix large, heart-shaped, with somewhat elongate-pointed anterior end. Signum a linear band of spicules merging to smaller spicules laterally, as a line between heart-shaped lobes, from ductus bursae junction to two-thirds distance to anterior end dorsally. Bursa with minute spicules over most of surface. Dorsal margin of ductus bursae-bursa juncture with patch of large spicules. Genitalia drawn from allotype (JBH pre. No. 256); 7 preparations examined.

Types.—Holotype male and allotype female: PATTERSON RESERVE, DEL VALLE LAKE [ROCKY RIDGE, 8 air mi. SSE. LIVERMORE], ALAMEDA COUNTY, CALIFORNIA, 3 Feb 1974, rearing 74B1, emerged ex *Cynoglossum grande* 23 Feb 1974 (J. A. Powell). Holotype and allotype with the University of California, Berkeley, deposited on indefinite loan at the California Academy of Sciences.

Specimens examined.—45 paratypes from California: Marin County: Alpine Lake, 25 Apr 1958 (1 ♀); Lagunitas, 17 Mar 1970 (1 ♀) (P. A. Opler).—San Mateo County: San Bruno Mts., 20 Mar 1970 (2 ♂) (Opler).—Contra Costa County: Tilden Park, Berkeley Hills, 16 Feb 1970, rearing 70B6, emerged ex *Cynoglossum grande* 28 Feb 1970 to 7 Mar 1970 (4 ♂, 4 ♀) *Cynoglossum* association, 16 Apr to 20 Apr 1969 (6 ♂, 13 ♀, Opler) Merry Go Round Hill, Berkeley Hills, 20 Feb 1973, rearing 73B2, emerged ex *Cynoglossum grande* 10–15 Mar 1973 (3 ♂, 2 ♀); MGR Hill-Wildcat Creek, Berkeley Hills, 7 Mar 1972, rearing 72C3, emerged ex *Cynoglossum occidentale* 22–29 Mar 1972 (5 ♀). Alameda County: Patterson Reserve, Del Valle Lake, 3 Feb 1974, rearing 74B1, emerged ex *Cynoglossum grande* 23 Feb 1974 (1 ♂, 1 ♀), 24 Feb 1974 (1 ♀); 17 Feb 1973, rearing 73B1, emerged ex *Cynoglossum grande* 6 Mar 1973 (1 ♀).

Additional specimens from California not designated as paratypes: "Placer Co.", 20 Apr (4 ♂, 3 ♀—USNM) (A. H. Vachell); 1 May (1 ♂—MCZ; 1 ♀—USNM) (Vachell); Cisco, Placer Co., 1 Jun 1905 (1 ♀—USNM) (Vachell).

All specimens were collected or reared by J. A. Powell unless indicated otherwise. Paratypes are deposited in the following collections: University of California, Berkeley, Canadian National Collection, Florida State Collection of Arthropods, U. S. National Museum of Natural History, and my own collection.

Specimens from the San Francisco Bay area show little variation, except that freshly emerged specimens have darker fuscous markings than flown specimens. There is one anomalous female from the type locality with the 2nd anal vein fuscous and with a spot at the discal end of the cell. This female approaches the more extensive fuscous hindwing scaling of some of the specimens (♂ and ♀) of the Sierra Nevada foothill population (Placer County). These latter specimens include some that have white hindwings as in the coastal population, others that have most of the hindwings fuscous, while some are intermediate. The dark-hindwing members of this Placer County population greatly resemble *Choreutis occidentella* Dyar, which is most closely related to *C. apocynoglossa*, but they may be distinguished by always having at least the anal margin to the 3rd anal vein of the hindwings white. *C. occidentella*

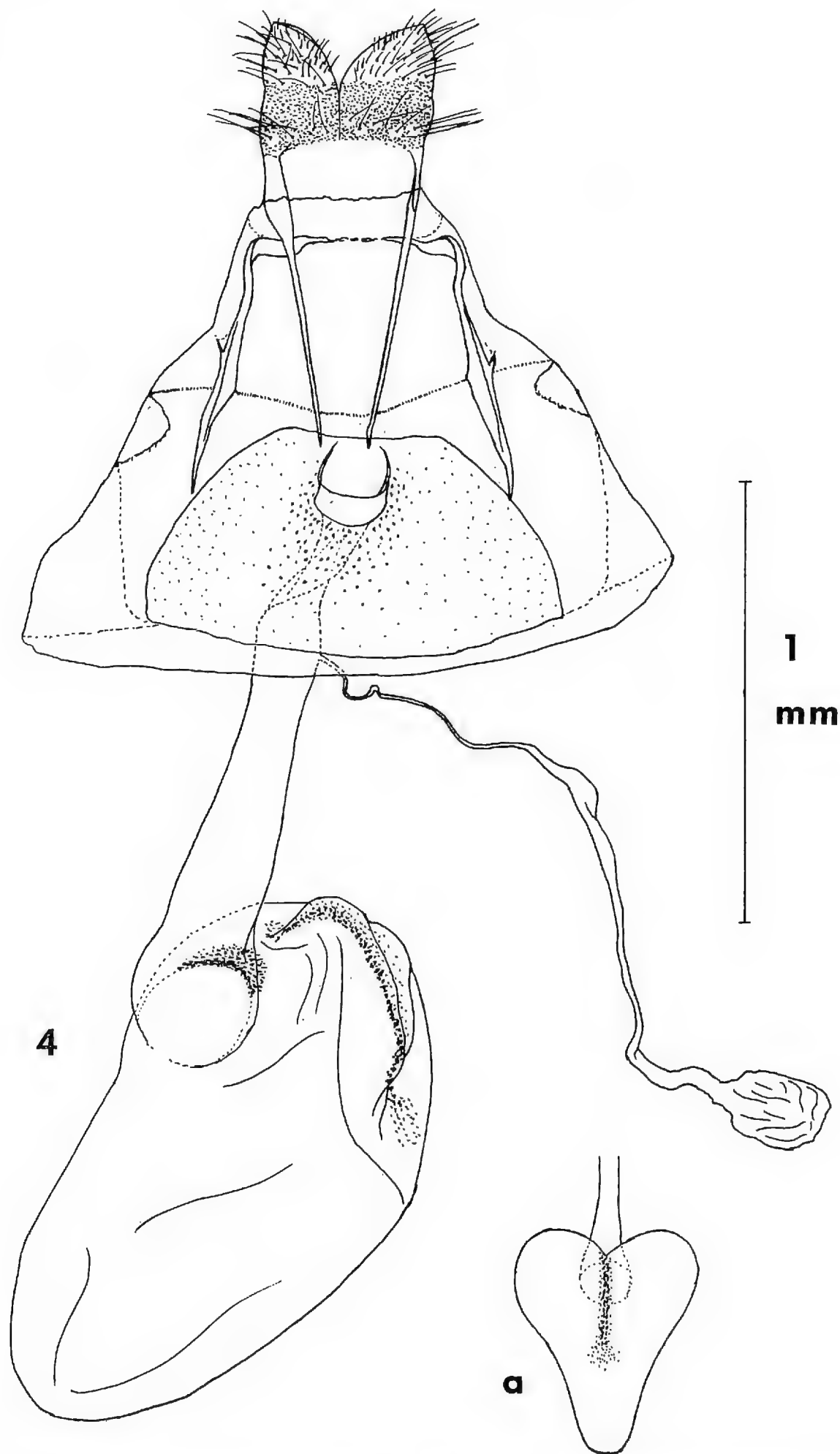


FIG. 4. female genitalia of *Choreutis apocynoglossa* Heppner allotype, ventral aspect; a, dorsal schematic of bursa copulatrix inflated (reduced scale).

has the hindwings uniformly gray-brown with no white scales. *C. occidentella* also has a consistently longer and thinner aedeagus, and a valval sacculus that is more produced at its distal end than in *C. apocynoglossa*.

Choreutis occidentella occurs throughout montane areas of the Rocky Mountains, from northern New Mexico to northern British Columbia, west into northern California and the Sierra Nevada. A series of melanic Colorado specimens, defined as *Choreutis coloradella* Kearfott, probably represents a high altitude form of *C. occidentella*, although a final clarification of the status of *C. coloradella* requires further investigation. The only known zone of possible contact between *C. apocynoglossa* and *C. occidentella* is in the Placer County area of the Sierra Nevada, although another likely contact zone would be in northern Lake County, which is adjacent to montane areas of Glenn County, the southern known limits of *C. occidentella* in northern coastal California. The darker hindwings of some members of the Placer County population indicates possible hybridization with *C. occidentella*. Since the exact status of the Placer County population of *C. apocynoglossa* is uncertain, the available specimens are not added to the paratype series.

Choreutis caliginosa Braun from Montana is superficially similar to *C. apocynoglossa* but may be easily distinguished by the very different genitalia. The Mexican *Choreutis schausiella* Busck, from Las Vigas, Mexico, but erroneously stated to be from New Mexico (Busck, 1906), is likewise similar to *C. apocynoglossa*, but the genitalia are very different and the adults are about half the size of *C. apocynoglossa*.

Flight period.—Mid-March to late April (San Francisco Bay area); late April to early June (Sierra Nevada foothills).

Biology.—Hosts: *Cynoglossum grande* Douglas and *Cynoglossum occidentale* A. Gray (Boraginaceae). The only other *Choreutis* known to have a host plant in the Boraginaceae is *Choreutis augustella* Clarke of the Pacific Northwest (Braun, 1940). Most other *Choreutis* species, where known, utilize Labiatae and Urticaceae, but the hosts remain unknown for the majority of the species. Most known *Tebenna* hosts are in Compositae. The hosts of species closely related to *C. apocynoglossa* are not known. Characteristic of *Choreutis* and related genera, *C. apocynoglossa* larvae pupate in an elliptical, flattened cocoon of silk formed in two layers. Pupal shells are extruded with adult eclosion. Immature stages will be described in my revision of the family. Collection sites in the San Francisco Bay area are typical Coast Range oak woodland habitats where *Cynoglossum* often is a common understory plant. While *Cynoglossum* occurs in open surroundings as well as

among dense oak stands, larvae of *Choreutis apocynoglossa* have thus far been found only on plants growing in deep shade (Powell, personal communication).

ACKNOWLEDGMENTS

For their helpful comments I wish to thank D. H. Habeck and J. Reiskind, University of Florida, and H. V. Weems, Jr., Florida State Collection of Arthropods, Florida Department of Agriculture and Consumer Services, Gainesville. In comprising part of my revisionary studies of the Nearctic Glyphipterygidae, this paper owes its completion in large part to the generous support provided by the Department of Entomology and Nematology, Institute of Food and Agricultural Sciences, University of Florida. My thanks also to curators of the Museum of Comparative Zoology (MCZ), Harvard University, and the National Museum of Natural History (USNM), Washington, D.C., for making material available for study. Finally I wish to thank J. A. Powell for providing most of the specimens for study from his collecting and rearing efforts, and for kindly making available biological information and larvae of the new species.

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SCIENTIFIC NOTES

Galápagos Moths.—The appearance of Hayes' well-illustrated publication on the larger moths of the Galápagos Islands (Proc. Calif. Acad. Sciences, series 4, vol. 40, pp. 145-208, 1975) represents a landmark in the study of Galápagos insects. Including the colored frontispiece which illustrates three adult female and two larval color phases of the common *Manduca rustica calapagensis* Holland (long known under the familiar generic name "*Protoparce*"), there are 157 photographs of adult moths representing all but two of the species treated, usually including both sexes and frequently melanic phases and other variants, and the male genitalia (in one case the female genitalia, also) of a few of the old species and all but one of the new species described. Thus, the opportunity is provided for the non-specialist to identify most of the species by habitus, at least tentatively, while actually engaged in field studies in the archipelago. Hopefully, it will stimulate use of these moths in ecological studies, including their role in the pollination of Galápagos plants (see Linsley, 1966, in Bowman, Proc. Symposia Galápagos Intern. Sci. Project, Univ. Calif. Press, pp. 225-232). Since many of the species visit flowers in the daytime or at dusk, their activities lend themselves

to observation with less difficulty than during the night. With the publication of Rindge's treatment of the Geometridae of the Galápagos (American Museum Novitates, no. 2501, pp. 1-31, 1973), only the Pyralidae and Microlepidoptera remain to be studied.

An interesting by-product of the Hayes' paper is an opportunity to judge, at least roughly, the impact of man in accelerating immigration and establishment of moth species from the mainland, as well as results from collecting by entomologists using both "black" and "white" lights and the rearing efforts of those resident for various periods at the Darwin Research Station on Santa Cruz (notably R. Perry, formerly Director of the Station, and Tj. deVries of the Zoölogisch Museum, Amsterdam). In these respects it may be instructive to make comparisons of the state of knowledge of the larger moths reflected in the list provided by Linsley and Usinger (Proc. Calif. Acad. Sci., ser. 4, 33: 113-196, 1966), which with the exception of the Sphingidae¹ which had been revised in 1962 and 1964 by Kernbach, essentially reflected the situation prior to the establishment of the Darwin Station.

If we confine our comparison to noctuids, Linsley and Usinger recorded 42 identified forms from the Archipelago, based primarily on the reports of Schaus and Richards published respectively in 1923 and 1941. Of these, nearly half (20) were regarded as cosmopolitan, pantropical or neotropical in distribution, the remainder as endemic species or subspecies. By contrast, Hayes records 72 species of which 33 are regarded as endemic forms (26 are treated as distinct species and seven as subspecies of mainland taxa).

Of the 20 widespread species listed by Linsley and Usinger, only four were then known to occur on four or more islands. Hayes' list, which was based to a large extent on material collected in the 1960's after the World War II airbase on Baltra had been established and abandoned in the 1940's and post-war commerce between the islands and the mainland had been expanded during the interim, included 39 species of widespread mainland occurrence,² 17 of which are reported from four or more islands. In spite of the fact that Hayes had available large amounts of material resulting from intensive collecting efforts by many individuals with more effective techniques and greater access to the individual islands than their predecessors, this fact alone could hardly explain the large number of previously unknown immigrant species represented in the recent collections. Much of it must be the result of the increased transport and commerce with the mainland. This is further suggested by the fact that almost all of the continental species recorded by Hayes from three or fewer islands do not appear in the Schaus or Richards lists. Many of the recent additions to the Galápagos noctuid fauna are economic pests elsewhere and some may well prove destructive in the islands. The well-known nature of the immigrant species is attested by the fact that of the 39 recorded by Hayes, 10 were named before 1800 and 18 before 1860 (of these 8 each were proposed by Guenée, 1852, and Walker, 1856, although three of the latter were revived or newly interpreted names).—E. G. LINSLEY, *Division of Entomology and Parasitology, University of California, Berkeley* 94720.

¹ Hayes doubtfully included an additional sphingid, a specimen of which was labeled "Galápagos and Cocos Islands" which almost surely does not occur in the Galápagos. Now it can only be removed from the list by cumulative negative evidence, like the cerambycid *Taeniotes hayi* Mutchler (see Linsley and Chemsak, Proc. Calif. Acad. Sci., ser. 4, 33: 233, 1966), a somewhat similar case.

² Four species listed in an addendum are not included in this tabulation since no data are available concerning their occurrence on specific Galápagos islands.

Suspected Cannibalism in Survival of Nymphs of *Triatoma protracta navajoensis*.—Ryckman (1962, Univ. Calif. Publ. Entomol., 27:168–69) reported a maximum survival period without a bloodmeal for 4th instar *Triatoma protracta protracta* (Uhler) of 309 days ($N=4$), and 193 days for 3rd instar nymphs ($N=4$). He postulated a 1,069 day maximum developmental period for nymphs if fed only at the end of the maximum survival period for each instar. Of 15 bugs recorded for instars 1, 2 and 3, he noticed that the well-fed nymphs which did not molt appeared to have a survival advantage of 1 to 10 days over those that did.

In moving stocks of *Triatoma protracta navajoensis* Ryckman in June of 1973 from Los Angeles City College, Los Angeles County, to Thousand Oaks, Ventura County, one cardboard box remained buried among boxes of laboratory equipment along the west wall of the garage. Of 658 nymphs sealed in the box, 5 survived to feed again on 17.IX.1975 at Thousand Oaks. One individual 4th instar survived 894 days, two 3rd instars 895 days, and two 4th instars 903 days after the last feeding in Los Angeles. These bugs had access to no food except other bugs. In order to remain alive, the surviving 3rd and 4th instar nymphs must have sucked the body fluids of their own or larger instars in these cultures. No record was made at the time of isolation of the stages in each culture. The dead bugs were recorded as to instar except for 189 which appeared to be mostly 3rd instars in a culture where there were no survivors.

One surviving 4th instar nymph was associated with six 5th and twenty-six 4th instar dead bugs. Two 4th were with fifteen 5th, thirteen 4th and five 3rd instars. Two 3rd were with eight 4th, forty-one 3rd and twelve 2nd instar dead bugs. Unfortunately, since all surviving nymphs were very flat, no evidence of color differentiation (body fluids or blood) could be discerned through the tan exoskeleton. Since the writer has shown that 5th and 4th instars of *T. p. navajoensis* can take meals of 248 and 119 mgm, respectively, their expected survival may be much longer than all other stages (Wood, 1976, Ann. Entomol. Soc. Amer., In Press). The maximum blood meal record for 3rd instars was 56 mgm.

Schenone *et al.* (1974, Bol. Chil. Parasit., 72:331–32), summarizing experiences with *Triatoma infestans* in xenodiagnosis in Chile, reported that the 4th instar nymph survives better than other stages. For *T. p. navajoensis*, two 4th or four 3rd instar nymphs would be as valuable as one 5th for xenodiagnosis because of their relatively large blood meals (Wood, 1976, loc. cit.).

The cannibalistic tendency of *T. p. navajoensis* may have increased survival value in relation to the canyon wall habitat of such localities as Chaco Canyon National Monument (Wood & Wood, 1961, Am. J. Trop. Med. & Hyg., 10:155–65). The numerous cracks and crevices of these massive sandstone walls offer exceptional protection to conenose bugs as well as native rodents. In such a location, much effort or undue exposure.—SHERWIN F. WOOD, 614 W. Shenandoah St., *Triatoma* can easily move in a secluded niche from one host to another without Thousand Oaks, CA 91360.

EDITORIAL NOTICE

The editorship of the Pan-Pacific Entomologist will change hands beginning with the October, 1976 issue (Vol. 52, No. 4). New manuscripts should be submitted to Drs. Thomas Eichlin and Alan Hardy, California Department of Food and Agriculture, Division of Plant Industry, Laboratory Services, 1220 N Street, Sacramento, California 95814.

THE PAN-PACIFIC ENTOMOLOGIST

Information for Contributors

Papers on the systematic and biological phases of entomology are favored, including articles up to *ten* printed pages on insect taxonomy, morphology, behavior, life history, and distribution. Excess pagination must be approved and may be charged to the author. Papers are published in approximately the order that they are received. Immediate publication may be arranged *after* acceptance by paying publication costs. Papers of less than a printed page may be published as space is available, in SCIENTIFIC NOTES.

Manuscripts for publication, proof, and all editorial matters should be addressed to the Editor, John T. Doyen, Division of Entomology & Parasitology, University of California, Berkeley, California 94720.

Typing.—Two copies of each manuscript must be submitted (original and one xerox copy are suitable). All parts of manuscripts must be typed on bond paper with double-spacing and ample margins. Carbon copies or copies on paper larger than $8\frac{1}{2} \times 11$ inches are not accepted. Do not use all capitals for any purpose. Underscore only where italics are intended in the body of the text, not in headings. Number all pages consecutively and put author's name at the top right-hand corner of each sheet. References to footnotes in text should be numbered consecutively. Footnotes should be typed on a separate sheet.

First page.—The page preceding the text of the manuscript should include (1) the complete title, (2) the order and family in parentheses, (3) the author's name or names, (4) the institution with city and state or the author's home city and state if not affiliated, (6) the complete name and address to which proof is to be sent.

Names and descriptions of organisms.—The first mention of a plant or animal should include the full scientific name with the author of a zoological name *not* abbreviated. Do not abbreviate generic names. Descriptions of taxa should be in telegraphic style.

References.—All citations in text, e.g., Essig (1926) or (Essig, 1958), should be listed alphabetically under LITERATURE CITED in the following format:

Essig, E. O. 1926. A butterfly migration. *Pan-Pac. Entomol.*, 2:211-212.

1958. Insects and mites of western North America. Rev. ed. The Macmillan Co., New York. 1050 pp.

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